DESIGN OF CONSUMER CONTAINERS FOR RE-USE OR DISPOSAL

SW3P

Proceedings of the Solid Waste Resources Conference on

DESIGN OF CONSUMER CONTAINERS FOR RE-USE OR DISPOSAL

May 12 and 13, 1971

This publication (SW-3p) reporting on papers presented at the seminar co-sponsored by Battelle Memorial Institute – Columbus Laboratories and the U.S. Environmental Protection Agency was compiled by **George F. Sachsel.**

U.S. ENVIRONMENTAL PROTECTION AGENCY
1972

An environmental protection publication in the solid waste management series (SW-3p) published jointly by two components of the U.S. Environmental Protection Agency – the Office of Solid Waste Management Programs (Washington) and the National Environmental Research Center (Cincinnati).

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price $1.75

FOREWORD

One of the characteristics of an affluent society is the exploitation of natural resources to produce and distribute to most of its citizens an overwhelming diversity of products, most of which eventually end up as solid waste. Because of a variety of factors--most of them related to population growth, urbanization, and affluence--the mere disposal of this solid waste, be it by sanitary landfill or a combination of incineration and sanitary landfill, is becoming more costly.

The increasing diversity and complexity of the many components of solid waste has posed problems not only in disposal but in reclamation as well. This Solid Waste Resources Conference attempted to address itself to the disposal and reclamation of a segment of solid waste that has been growing more rapidly than the rest--consumer containers, or packaging. Among the many possible responses that might alleviate the impact of this segment is design of consumer containers to facilitate their reuse or disposal. Several of the speakers at the conference addressed themselves to this specific topic, ranging from the package designer's viewpoint to research reports on "self-disposing" containers. Some questioned the concept from standpoints of marketing demands or particular resources considered renewable. All of the speakers addressed themselves to one or more aspects of the reuse or disposal of packaging materials. The conference was also characterized by a wide representation, both among the speakers and the audience. Dialogue among members of industry and commerce, academic institutions, Federal and local government, private-citizen groups, and communications media yielded some potential solutions and identified a number of problems.

The main achievements of the conference may well have been that we developed an appreciation of the complexity of the problems and of the need for a multidisciplinary attack in the broadest sense--an attack calling for the efforts not only of scientists and technologists but of members of almost all segments of society. It is the intent of the cosponsors to hold similar solid waste resources conferences on selected topics at approximately 2-year intervals in the belief that the interaction of many segments of society may be the best approach for turning problems into opportunities.

--GEORGE F. SACHSEL
Technical Program Coordinator
Solid Waste Resources Conference

PREFACE

This volume is based on a symposium held May 12 and 13, 1971, in Columbus, Ohio. Each of the four parts of these proceedings, corresponding to the sessions of the symposium, brings together current knowledge and thinking in the disposal and reclamation of consumer containers.

The symposium was sponsored by the division of research and development of the solid waste management program, U.S. Environmental Protection Agency, and the Battelle-Memorial Institute's Columbus Laboratories. The research function of the solid waste program has since been assigned to EPA's National Environmental Research Center in Cincinnati.

The concept of national environmental research centers brings to the total environmental problem the combined technological expertise of laboratories that formerly focused only on one particular aspect of the environment. The Center in Cincinnati, one of three in the country, is presently organized into four major areas for research—air pollution, water pollution, radiation, and solid waste.

There were many who contributed to the success of the symposium. To all of them we are grateful and express our thanks.

Andrew W. Breidenbach
Co-Chairman, Solid Waste Resources Conference

December 1971

SYMPOSIUM COMMITTEE

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SESSION II – PLASTICS, COMPOSITES AND PAPER
J. H. Lindholm, Battelle's Columbus Laboratories

SESSION III – GLASS CONTAINERS
C. A. Clemons, Environmental Protection Agency

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OVERVIEW

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A. W. Breidenbach, Director
Division of Research
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U. S. Environmental Protection Agency

PACKAGING AND SOLID WASTE MANAGEMENT

Hugh H. Connolly
Office of Solid Waste Management Programs
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The growth of packaging in the United States has been a phenomenal one. It began during the period of the industrial revolution with the development of such items as the metal can, the collapsible tube, and the folding carton. During the period between 1900 and 1930, flexible packaging was born through the introduction of such items of kraft paper, cellophane, and aluminum foil. During the ensuing search for development of new packaging materials, there began a flood of packaged products that has never stopped growing in volume or variety.

Along with this growth has come a great deal of inventiveness, well documented by such achievements as the flip-top box, the pull-ring can, the push-button aerosol, the spray-on bandage, etc. There is no doubt that this is truly the era of "convenience packaging." However, these accomplishments in growth and inventiveness are also accompanied by a sizeable growth in contribution to the solid waste load.

For example, in 1966, 52 million tons of packaging materials were produced and sold in the United States. Of this massive tonnage--made up of many billions of individual units, most of them weighing much less than a pound each--about 90% entered the stream of solid wastes that had to be disposed. This figure was well above the 1958 packaging materials consumption of 35 million tons, and well below the expected 1976 consumption of 74 million tons.

Packaging is increasing in quantity much more rapidly than population. Per capita consumption of packaging materials was 404 pounds in 1958, 525 pounds in 1966, and is expected to be 661 pounds by 1976. Many factors underlie this dramatic increase, but chief among them is the continuing rise of self-service merchandising, creating a growing need for packages that sell the product without the help of a sales clerk. This accounts for much of the quantitative increase. Qualitative changes will be brought about by the need for improved product differentiation by packaging methods, the rise of many new food products which call for unique packaging, and the vastly expanded choice in materials provided the package designer by the advent of plastics and other relatively new packaging materials.

These packaging materials are made principally of paper, glass, metal, wood, and plastics, with the last-named being the most recent contestant in the field and the fastest growing. It is anticipated that by 1976, paper and board will continue to dominate the packaging field with 57% of the total on a tonnage basis. It is further estimated that glass will have 18% of the total, metals 13%, wood 7%, and plastics 5%.

It is significant to note that, of the 360 million tons of residential, commercial, and industrial solid wastes generated today, approximately 13% is discarded packaging material. In a typical year, Americans throw away 48 billion bottles, 4 million tons of plastics, and 30 million tons of paper. The very strong relationship between packaging waste and the peculiarly difficult problem of roadside littering has been well established by several surveys.

Nearly all the States in our country have enacted anti-litter laws which provide for both fines and imprisonment for the violator. However, these laws are very ineffective, for the violator is seldom apprehended. The ultimate solution to the litter problem will come only with successful educational programs designed to enlist public cooperation and citizen pride.

Of packaging materials being consumed today, approximately 50 million tons are being discarded as waste; only about 10% are being returned for reuse or reprocessing into new products. Collection and disposal of this tonnage is costing the nation in excess of $450 million. Assuming no increase in the unit costs of collection and disposal, which is highly unlikely, expenditures toward this end for packaging materials is expected to stand at nearly $600 million in 1976.

It has become perfectly clear that steps must be taken to mitigate the problems created by packaging materials in waste management. Where it is feasible to do so, we must reduce the destruction of valuable natural resources from which packages are made. In all cases, we must reduce the technical difficulties involved in processing packaging wastes.

In a report* prepared for our Office by the Midwest Research Institute, five potential mechanisms were discussed as possible avenues to the mitigation of these problems. These mechanisms are: (1) regulation, (2) taxes, (3) incentive and subsidy programs, (4) educational efforts, and (5) research and development. I would like to look briefly at each of these in turn.

Regulation, as herein used, means any legislative measure enforced by the executive arm of the government which imposes some action on package materials producers, packagers and/or users. Midwest Research Institute concluded that regulation of packaging would be the most effective mechanism to accomplish the objectives, though it may be a difficult one to justify. Given the tremendously complex nature of packaging, regulation, to be effective, would tend to embrace all activities directly and indirectly concerned with packaging. The costs of such a program appear to be potentially greater than the benefits that may be expected.

Let's look at plastics, for example, which, in addition to their rapid growth, are permeating the entire packaging field. Why not legislate against the use of plastics in

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* The Role of Packaging in Solid Waste Management--1966-1976.

any form of packaging materials? How would this affect us in our daily lives? We could go back to buying milk in glass bottles which would be returned to the store or be picked up by the dairy which delivers to our doors, rather than have the convenience of the plastic-impregnated paper cartons. We could get along without the plastic bottles and tubes containing shampoos, hair dressings, toothpaste, cosmetic items, medicinals, etc. that we use so many of, and go back to the glass and metal containers that were previously used for this purpose. It might be less convenient, and perhaps more costly, but we could do it. We could dispense with plastic-impregnated paper for frozen goods, too, and either buy all such food products in cans or, in the cases of fruits and vegetables, in their fresh form when they are in season. There may be times of the year when we couldn't eat the things we like, and we may have to sacrifice a little taste quality here and there, but we could make out. Meat packaging may have to go down the drain, and the old-fashioned butcher may well be back in style, but we could live with that. Many children's toys would have to be done away with, or be made of more expensive materials, but kids have too many toys anyway and could get along with much less.

Everything I have suggested here says "go back"--go back to the old ways of doing things. It means giving up those many conveniences that have become so much a part of our way of life--those things that have been made possible by the great advances in the technology of plastics production. Is this what we want to do--to return to the technology of the 1930's? Is this the only alternative we have available? I say emphatically no! The technology that produced these conveniences can, I feel certain, likewise solve the environmental problems caused by them. I believe we can, in this case, "have our cake and eat it."

Under the heading of taxes, two types are discussed --a use tax, imposed on all packages, and a deterrent type tax selectively imposed on specific materials. A packaging use tax would not directly result in reduction of package material use, reduction of processing difficulty, or in elimination of destruction of natural resources. It would, however, create the economic wherewithal for the processing of these wastes. Justification of a use tax would be easier than justification of a deterrent tax. For maximum effectiveness, however, a packaging use tax would call for extensive administrative machinery.

Take, for example, the packaging tax recently proposed by New York City's Environmental Protection Administration to be collected at the wholesale level on all types of packaging materials. This would be a graduated tax based on an evaluation of the difficulty of disposal of each major type of material. Whereas glass bottles would be taxed at 1.3¢ per unit, plastic bottles would be taxed at 2.0¢ per unit. Steel cans and aluminum cans would be taxed at 0.5¢ per unit and

0.25¢ per unit respectively. Other packaging materials made of paper would be taxed at 2.3¢ per pound, and plastic packaging would be taxed at 3.8¢ per pound. To me, this sounds like an administrative nightmare.

A deterrent type tax would be limited in effectiveness. Such a tax would of necessity be discriminatory since it would be imposed selectively. A deterrent tax serves, in effect, as a form of indirect regulation. Direct regulation is probably more desirable.

Various forms of incentives have been used by the Federal government for decades to achieve desired objectives. Incentives, as herein used, would be any expenditures of tax receipts made by the government, or use of the government's purchasing power, to bring about changes in packaging materials use or reuse. Expenditures could be either direct (subsidies, grants, price supports) or indirect (tax credits). For example, the Federal Government, as one of the largest purchasers and users of packaging materials, could formulate regulations banning purchase of non-returnable beverage containers. Tariffs on certain imported materials might be increased thus encouraging a switch to other materials. Depletion allowances for certain mineral resources might be reduced, thus encouraging heavier reuse of these resources. Any such potential incentives should be subjected to close study and scrutiny before being put into effect. Blind action could do more harm than good.

Two contracts were recently awarded by our Office to carryout some of the essential economic studies recommended. The first is for a "Study of the Incentives for Plastic Recycling and Reuse". Its objectives are to: (1) develop a number of complete strategies to be applied to the total system to improve recycling and reuse; (2) evaluate each strategy from a systems approach, taking into consideration the probability of success, administrative problems, legal constraints, and economics; and (3) select the best strategy.

The second is for a "Study of the Incentives for Tire Recycling and Reuse". Its objectives are basically the same as those for the plastics contract. It is anticipated that similar studies will be carried out relating to paper, glass, metals, organics, etc., or studies might be more specifically aimed at such items as junk automobiles, beverage containers, etc. Having a detailed picture of the economic situation before us, it will be much easier to make rational recommendations regarding use of incentives and/or disincentives.

Educational programs discussed by Midwest Research Institute are directed at three groups--industry programs, consumer education, and intra-government information programs. Basic to all of these is the assumption that one of the constraints to action on the part of those involved is unfamiliarity with the problems created by packaging. Once the problems are fully understood, voluntary action to mitigate them may be forthcoming. This assumption is certainly optimistic but, to a degree, sound.

Educational programs aimed at both industry and consumer groups are being carried out by such organizations as Keep America Beautiful, Glass Container Manufacturers Institute, National Educational Television Network, and others. Our office is supporting educational efforts both through extensive publication of its work and film documentation of its more successful projects. We hope to expand these efforts in the near future.

The research and development mechanism is certainly a key factor in the reduction of difficulty in processing waste packaging and in promoting reuse and recycle of packaging materials. Three types of research and development are possible: (1) research on materials and containers; (2) research devoted to improving salvage and reuse; and (3) efforts aimed at improving disposal technology.

Midwest Research Institute concluded that materials research does not offer foreseeable near-term success, but if sufficient resources are devoted to this area, perhaps the picture can be changed. A few projects of this nature have, hopefully, set the tone for future endeavors. We are all aware of the two new plastic materials for beverage containers known as "Lopac" and "Barex 210" which are being test-marketed by Coca Cola Company and Pepsi-Cola Company, respectively, as substitutes for polyvinyl chlorides. These, along with a third such material--XT polymer--offer similar characteristics with regard to gas permeation resistance, transparency, inertness, and rigidity for which acrylic plastics are noted, and suitable for the same general uses.

Most of you are aware, too, of the work going on at the University of Toronto in Canada and the University of Ashton in Birmingham, England, with regard to development of a biodegradable plastic. These efforts involve the use of "sensitizer groups" in the polymer chain which have the property of absorbing the ultraviolet light of the sun and using this energy to break the polymer chain, thus causing brittleness and susceptibility to attack by microorganisms. Though these efforts may not yet be considered major break-throughs in materials research, they are indications that progress is being made.

In this same area of materials research, a Solid Waste Management Office grant to Clemson University, South Carolina, is supporting research to develop a one-way container made basically of a water-soluble glass that may be dissolved after the container is emptied. The Project Director, Dr. Samuel Hulburt, will be discussing the details of this project later in the conference.

The Solid Waste Management Office supports a number of projects devoted to improving both salvage and reuse and disposal technology. For instance, Stanford Research Institute was engaged to determine the technical feasibility of an air classification process to separate non-homogeneous dry solid waste materials. A pilot air classifier has been constructed for separating five such materials. This unit operates on the principle that a sufficient velocity of air passing upward through the mixed wastes will achieve separation as a function of particle size, configuration, and specific gravity.

A wet pulverization system designed to reclaim fibre from municipal refuse has been developed and is now under demonstration on a pilot-scale system. In this system, the incoming solid waste is dumped into a storage hopper from which it is fed continuously into the hydrapulper where, through a pulping action, it is forced through 1/2 inch holes. Heavy inorganic materials are removed by a bucket elevator. The pulped material passes through a liquid cyclone to separate heavy materials such as dirt, glass, and small bits of metal. The remaining organic material passes to a series of screens which progressively concentrate the paper fibre. It is estimated that 200 tons of paper fibre, 80 tons of ferrous metals, and 80 tons of glass cullet would be reclaimed from each 1000 tons of solid wastes.

At Louisiana State University, a pilot plant has been designed which is successfully turning cellulose (bagesse) into single-cell protein. The development of the pilot plant followed the discovery of LSU scientists of a microorganism that breaks down waste cellulose into protein. Additional work is being conducted to refine processing techniques and analyze the protein products for digestibility and nutritional value.

It has been demonstrated that waste glass can be used as an aggregate in bituminous mixtures for street maintenance and paving. Glassphalt, the name given this mixture, has the potential of solving urban glass waste disposal problems. The Project Director, Dr. Ward Malisch, will be discussing the details of this project later in the conference.

Where do we go from here? It is quite obvious to me that the role of packaging, which has had such a meteoric rise, is not about to decline. We are all fully aware of the part played by packaging as both a marketing tool and a major contributor to profitability. It is practically assured that packaging is destined to play even a bigger and more important role in the years ahead. There is fair evidence, for instance, that automated supermarkets will become a reality of the 1970's, with pallett loading stocking of shelves and automated checkout. Packaging techniques will play a key role in these developments if they are to succeed. Another area likely for development is portion-packaging for single servings in countless products, food and non-food, as more individuals in the family lead their own busy lives and want no-fuss meals on the run.

In view of this, then, what action must the Federal Government take during the 1970's to eliminate future problems caused by packaging wastes? There are many paths open to it, some of which have been suggested in the form of legislation introduced for consideration. It could restrict production of certain packaging materials, ban no-return beverage containers, impose severe disposal taxes on all packaging materials, etc. Or it could lead the way in assuring new developments in packaging which will allow our continued use of these materials at the desired levels without future injury to the environment.

The recently enacted "Resource Recovery Act of 1970" gives a good indication of the route the Federal Government will take. This Act provides funds for extensive research toward: uses and outlets for recovered wastes; modification of product characteristics to enhance recycling; improved collection, separation, and containerization; use of Federal procurement to develop market demand for recovered resources; incentives and disincentives to accelerate reclamation of resources; effects of existing public policies upon the recycling of materials; and the necessity of imposing disposal charges on packaging, vehicles, and other manufactured goods. The Act also provides funds for demonstrating resource recovery systems, improvements in such systems, and related technology. It is clear that the Federal Government expects to find solutions to the problems by routes other than restrictive legislation against the source materials if at all possible.

However, though we feel the Federal funding related to problems of packaging waste may well yield beneficial results, it is not enough. The industries that produce packages and packaging materials must shoulder part of the responsibility for financing research to devise packages that are compatible with recovery and disposal processes. We can no longer tolerate the attitude taken by some that industry's responsibility is solely that of providing consumer items to the American public which are aesthetically pleasing, efficient, durable, and at lowest possible cost, and that disposal of these items after use is solely the responsibility of the user. When new packaging products are developed, the developing industry must consider waste management problems in addition to the items of durability, consumer appeal, and economy. For products that are on the market today, methods for recovery, reuse, and/or ready disposability must be devised.

We believe that it will not be necessary to make a drastic change in our mode of living away from the trend of convenience packaging and "throw-Away" habit. However, we will have to look closely at packaging of various types to determine if the materials used have sufficient present or potential value as candidates for recycling processes. As the earth's available resources dwindle, the acceptability of convenience packaging may be governed by a different set of priorities. Certainly, we must find the appropriate recycling or disposal mechanism for each material.

Hopefully, this conference will provide some of the answers necessary to moving us along the correct path toward our eventual goal.

RECYCLING – STATUS AND OPPORTUNITIES

M. J. Mighdoll
National Association of Secondary Material Industries

Recycling--a word not even to be found in many dictionaries and encyclopedias--has suddenly become a household term. Recycling--an age-old science of utilizing waste materials--suddenly is "discovered". Recycling in just a period of months, has been embraced by environmentalist and industrialist, by politician and educator.

And well this might be the case. . . for recycling is the most constructive response we have yet developed to answer the challenge of environmental management... to cope with the mounting piles of solid waste building in direct proportion to our population growth and industrial productivity.

Today, I have been asked to speak on the present status of recycling and its future opportunities . . . and to specifically relate the present and the potential to containers. Interestingly enough, the challenge of this effort is not in describing the present status of recycling or in projecting future opportunities for it. The challenge lies in defining and undertaking the actions that will be needed to close the gap between recycling concept and recycling reality.

I am sure that there are few in this room that need to be reminded of the horrors of solid waste. There have been enough doomsday pictures and literature, enough statistical evidence that solid waste is indeed as fearsome a pollution menace as that related to air and water.

And if we accept the seriousness of the solid waste problem--if we have studied that problem at all--we know that containers--packaging of all types--represent one of the most serious sources of solid waste. The soap box, the milk carton, the shipping case, the soda bottle, the beer can, the plastic bubble--we've seen them all in the pollution pictures and analyzed in the statistical surveys of solid waste. Yes, America, the discarded container is there . . . it is solid waste enemy No. 1 . . . it is a victim of our own modern society . . . it must be captured and controlled . . . but how?

Are there many among us who would seriously suggest we ban the can? That we abolish the container? That we legislate the package into extinction?

No, if we are to be realistic--and if we desire to deal effectively with the solid waste problem today and in terms of the affluence and sophistication of our society, then we must certainly accept a few critical facts.

We must accept the fact that solid waste, however much we minimize its quantitative growth through organized effort, cannot be planned out of existence. Solid waste will always be produced as a corollary of industrial production and life itself. It can, however, be qualitatively controlled. Recyclability can be introduced as a public mandate; industrial production need not be conditioned solely on marketability.

Secondly, we must accept the fact that solid waste materials must be thought of in affirmative and constructive terms, not negative ones. We must acknowledge that burning and burying waste comes after efforts are made to utilize it, not before. We must, in short, establish our priorities correctly--and that would certainly seem to dictate a much greater orientation to recycling, not disposal, activities and incentives.

Thirdly, we must accept the fact that recycling is not an act of magic. It holds no miraculous power that transcends the laws of economics. We must, therefore, agree that recycling, the utilization of solid waste, requires and is entitled to the strongest and most comprehensive economic support we can give it. In oversimplified terms, every ton of solid waste that can be recycled is a ton of new raw material recovered with a profit factor, not a ton of waste to be disposed of at a substantial cost and with a resulting loss of natural resource conservation.

Therefore, if we will accept these hard facts of life, we can only come to one conclusion: that recycling as a positive and primary response to the solid waste problem must be given a new set of conditions. Recycling must be encouraged through every economic, technological, legislative, and psychological means at our command.

This alone represents a reversal of priorities. Our history unfortunately has been one that either ignored the role of recycling or--even worse--permitted the construction of economic roadblocks and disincentives to waste utilization.

Thus--as we take a look at the status of recycling, we are truly looking at an amazing industrial phenomenon . . . One that occurred on the dark side of this planet, such was the lack of public or governmental concern, except for a few wartime years . . . one that occurred purely as a result of economic need, for there was no ecological urgency, no national concern with dwindling natural resources throughout the past decades.

Truly an amazing phenomenon . . . here is the recycling industry today: supplying more copper and lead each year than is mined from our country's soil . . . providing a third of the nation's aluminum, a fourth of its zinc, a fifth of its paper.

For a number of decades, the secondary materials industries in this country have been recycling metals, paper, textiles, rubber, glass--hundreds of recoverable materials. It all began with a scattering of small businesses, which have since grown up in this century. They matured, developing highly complex techniques and sophisticated processes. They invested in new technology and volume-oriented equipment, expanded research facilities, found new market outlets. They built a major industry, one which today operates at an $8 billion level annually.

The recycling industry was there . . . in those "dark" years, when its contributions to the economy were cloaked in anonymity . . . when it was not commercially advisable to say "rag content" paper--so we had "cotton fiber content" . . . when it was more discreet to say "wood pulp substitute", not "waste paper".

The recycling industry was there . . . in the unfortunate wartime years, when it led great national efforts to reutilize materials in short supply. . . when it taught new lessons in economics and technology to those who said "it can't be done".

And here it is in 1971 . . . having not only survived the hot-and-cold attitudes of an illusive public, the cyclical now we need you-now we don't policies of manufacturing industries, and the less than consistent policy-making of Government.

Yes, here it is--alive and well in 1971--but now challenged to perform a role of mountainous proportions, as big as that very solid waste mountain we've had so dramatically pictured for us.

But this present status of the recycling industry --and the present conditions under which it operates--cannot be expected to single-handedly win the new war on solid waste. The "discovery" of recycling is one thing; understanding and effectively applying it to the whole solid waste spectrum is something else.

"Recycling" is such a simple word. But how complex it is in terms of the economic-technological interrelationships it involves. How complex it is in terms of consumer purchasing habits, in terms of the kind of legislative turn-arounds that are needed. If only one thing has become obvious to those recently initiated into the world of recycling, it is that "recycling" is not synonymous with "collecting". They soon learned that recycling is directly linked to our ability to utilize increased quantities of recycled material in existing markets and a broader range of products--and that this recycling expansion is itself linked to a new set of conditions . . . some "new rules" in economics, new technological developments, new thinking in government circles, new attitudes on the part of the consuming and waste-generating public.

There are no short cuts, no curative or preventive pills. The answer to transcending from present status to future opportunities lies in change . . . the kind of change that will promote recycled materials use, not more virgin supplies . . . that will favor use and reuse, not use and discard . . . that will encourage a constructive public response and thus initiate purchasing habits that will trigger industrial action in the form of new raw materials use policies.

Since paper constitutes the largest single element in solid waste, it represents a revealing case in point. Let's look at waste paper--the tens of millions of tons of it that are discarded each year--a large percentage of which, perhaps half, comes from packaging . . . containers of all types and sizes.

What has happenea in this paper container field is astounding--and it represents the best evidence for the change that is essential to successful recycling of this solid waste.

In the decade of the Sixties, the use of paper by every one of us grew at an unprecedented rate. Led by the packaging field, paper use by 1970 hit a peak of 500 pounds per person a year. We thus reached a new peak in production and a new low in recycling . . . because while we Americans used 58 million tons of paper--the largest amount ever--we recycled less than 20% of it . . . in fact, almost down to half the percentage rate for recycling during the 1940's, when there was a much lower total volume of paper produced. In short, we have been guilty of double jeopardy . . . we use at the highest rate in the world, and recycled at proportionately the lowest.

What is even more revealing is the raw materials use policies of the paper industry. In those same ten years of the Sixties, the rate of virgin pulp use outpaced that of waste paper at a 3 to 1 ratio. Where waste paper had supplied 26% of the total raw material furnish of the paper and paperboard industry in 1960, it was down below 20% by 1970.

Look at the paperboard industry, where containers are manufactured. This segment of the paper industry has traditionally represented the largest single market for waste paper, and especially the bulk grades found in municipal waste. In 1960, about 42% of all containerboard was made from "combination board"--that made largely with recycled fibers. By 1970, this important market had decreased to a 28% level. In other words, in the short space of ten years, the largest single outlet for waste paper had shrunk by one-third.

More production, greater use, larger waste generation--but less recycling. Certainly not a desirable situation; certainly a recycling status in need of change.

Look at other fields involving containers. Look at aluminum, where the production of aluminum cans increases annually, with little regard for economically viable or technically feasible recycling. Metallic containers--with all the convenience of a design engineer's imagination can create and a production line can produce. Marketability, not recyclability, is the motivation--and so we have bimetallic containers which defy effective reuse.

On and on could go the examples indicative of a lack of concern with the recyclability of containers or the use of their recycled elements in new products.

And yet containers can be recycled. They can be a new material resource, not a solid waste or litter problem. Let's go back to our paperboard container example. Corrugated containers and other paperboard cartons can be recycled directly into new containers and packaging products. In fact, a large percentage of municipal waste consists of such containers. And, on the other hand, a large market exists for new containers. The obvious question then is: why isn't a larger percentage of these recyclable materials used as new raw material furnished by the paperboard industry?

And that question, gentlemen, brings us to that gap I spoke about at the beginning of this presentation. That gap--the difference between the status of recycling today and the potential it can have--must be the focus of our attention. The ultimate success of recycling in responding effectively to the solid waste problem is dependent on the steps that are taken--not talked about--to permit the recycling opportunities that are possible.

These opportunities we envisage can only become reality with the changes to which I refer. We need changes--some basic, and perhaps radical, changes in our thinking. We need changes in psychological attitudes among consumers about the value of products made with recycled materials . . . changes in Government policies relating to purchasing specifications that discriminate against recycled materials . . . changes in industry attitudes regarding responsibilities in balancing recycled and primary materials usage . . . changes in attitudes by well-intentioned citizens, who see in the act of collection of waste materials the cure-all solution to the solid waste problem . . . changes in tax laws that favor primary resources industries and thus serve to impede the economics for recycling.

Some of these positions are so ingrained that it will take a concentrated effort to revise them. But we must--for change is imperative if we are to translate our success in utilizing industrially generated waste to successful recycling of packaging products on a public level.

The urgency of removing biases and prejudices and installing incentives is critical to successful recycling. Isn't it surprising that the Federal Government--the largest single generator and seller of waste materials--still prohibits or limits the use of recycled materials in many of the products it purchases? Doesn't it amaze you that we demand solid waste collection and more recycling in our cities--and then construct municipal regulations that remove the companies equipped to do this from the urban community? Is it not incongruous that we consumers discard a box, a package, a container--and yet do not direct our new purchase power toward products that use these materials again?

For too long we have lived with a philosophy based on limitless natural resources. Now we know better. New concern--concern with both our environment and the limitations of land and trees--has bred some new thinking. We are now experiencing the first positive steps to close that recycling opportunity gap. The needed turn-around is now underway--and it is already visible in the declared actions of Government, the public, and industry.

It is visible in New York--where back in February Mayor John V. Lindsay declared: "the deck is stacked against the recycling industry. We must end it now. We intend to redesign our entire purchasing system to include a preference for recycled products". And in these last weeks, New York City became the first to actually buy some of its products with a required recycled materials content in their specifications.

It is visible in Washington, where the General Services Administration and other Federal procurement agencies are responding to President Nixon's directive--a directive that called for a "reversal of the trend".

It is visible in industry--where company after company, sensing the will of the public--is orienting purchasing policies to recycled materials.

It is this kind of action that will broaden the markets for recycled materials and create the favorable economic conditions that will in turn broaden the recycling horizon for containers. It will also expand technological development, because it is only with a favorable economic atmosphere that technical study and research effort will be undertaken. And it is important that such research be initiated; it will lead to greater adaptability of recycled raw materials to a larger range of industrial products . . . it will bring about truths, instead of myths, relative to the performance standards of products made with recycled materials.

Ahead are studies of this country's tax structure, which presently encourages the harvesting of trees--at the direct economic disadvantage of waste paper . . . which presently makes it more profitable to use virgin wood pulp rather than recycled containers.

Ahead are more comprehensive policies linking what municipalities generate as solid waste and that which they purchase as new raw materials and products . . . linking what industries manufacture as products and that which can be recycled . . . linking this country's future raw materials policies with environmental and conservation realities.

Ahead is a new wave of public concern . . . a public response that will represent a demand factor as great as any consumer reaction we have known. The public has been in an informational vacuum: it has had a poor understanding of the dimensions of the solid waste problem or the options open to the public sector through recycling. My Association has taken a leadership role--and I am pleased that we are now being joined by Government, environmental, and other industry groups--to inform the public. In view of the social cost of present solid waste management, and the added burden the future portends, can there be any doubt that the public deserves the facts? . . . and the opportunity to respond through a recycling purchasing orientation?

Ahead lies stronger municipal and state action . . . and here we must hope the logic, not hysteria, is in command. We must exert efforts to evolve the kind of regulations which will advance solid waste utilization, not impede it. Premature packaging taxes or other so-called control devices must not be hastily instituted as a guise for dealing with the solid waste problem. Overnight solutions will not be found to resolve the solid waste problem, and the penalty approach cannot serve as the alternative to what is really required: a program that establishes the economic and technical opportunities for expanded recycling and assures the most effective use of all the raw materials this nation possesses.

Yes, there are recycling opportunities. I believe what we are witnessing now is but a scratching of the surface for recycling's future. What we are experiencing now is an awakening to the problem and a recognition of the needs.

We have found that the nation does care enough to put action where before we had only rhetoric. With positive action, such as I have described, recycling represents a great potential and real promise. Today's discarded box can be tomorrow's container: recycling--economically and technically sound recycling--will make it so.

PACKAGING AND ENVIRONMENTAL PROTECTION*

Joseph M. Murtha
Sandgren, Murtha, Lubliner Inc.

Some men like golf and fishing, but I find that my hobby has become attending environmental conferences. I became active in the field about a year ago when I went to one that lasted three days and three nights, and when I realized that you couldn't scratch the surface after three days and three nights I started to go to shorter sessions. But I have attended them from Paris to Portland, and I am afraid that in attempting to solve our solid waste problem we may be creating a larger one, for we have to add to it the companion concerns of land, sea, natural resources, and certainly the tremendous problem of verbal pollution about pollution.

In fact, if we could only harness the vocal energy that has been spent on this subject, we may be able to clean up the problem of solid waste over night. As Will Rogers said, "all I know is what I read in the papers," and from them I've

*Note: Instead of a formal speech, Mr. Murtha's subject was treated as a slide presentation, and his remarks at our conference and throughout this text were related to a variety of visual materials which could not be reproduced herein.

been soaking up information like a sponge. I bring you no technical expertise this morning. However, I have confidence that industry and the government will, in time, resolve many of the problems that we're discussing. I would just like to share with you some impressions that I have gained, both as a consultant to consumer product companies on packaging and from attending all these conferences.

Frankly, I am appalled at some of the irresponsible remarks that are made by representatives of various groups interested in the subject of solid waste disposal. I am a little concerned that we are starting to see--for a subject as vital as this to our National interests and our individual lives--vested interests, pressure groups, and marketing competition for attention which is creating a rather sad misconception with the consumer. Certainly the packaging industry has been buffeted on all sides by consumerism, which is against packaging puffery, and by conservationists, who are against packaging pollution and the irresponsible use of our raw material supplies.

In addition, of course, all levels of the industry have some economic concerns and well they might. Can you imagine, for example, what might happen if a major food manufacturer insisted that a given percentage of the packaging supplies they send on to the consumer would have to be reclaimed and recycled? It could create chaos over night.

Consumer companies are concerned about other things, too. What is the effect on brand loyalty as consumers start to measure some of their own ecological criteria for the package that they buy every day? We've been reading in the press quite a bit about that subject. One of our major clients had a bunch of young tigers, mostly product managers, form a consumer protection committee on their own with no authority, but to make recommendations. They also requested top management to allow them to constitute a package planning committee which would set standards, ecological standards, for every package that that huge corporation distributes through retail stores. So there are reasons for concern, business reasons, and economic reasons, as well as our own social reasons.

The dialogue is increasing in volume and intensity. Industry and government are talking to each other, and they also are doing a lot. It takes a great deal of time, as we know. My first impression is that we are, however, ignoring the consumer. We're talking down to them quite a bit.

If you analyze the packaging industry's advertising over the past six months, and then if you attended a lot of conferences, you might be astounded by the fact that there isn't much consistency in what they are trying to tell the consumer. This is also true about what their business concerns are, as they look towards further government activity at the Federal, State and local levels.

There has been virtually no research that I know of done on the level of consumer concern. We did a great deal of this in the '60's, when we were first promoting composite packaging and convenience packaging. We tested the consumer from every possible angle to find out where his levels of concern for convenience and cost were, and where the two axes would meet on the charts to indicate that he would be willing to pay 40% more for a package if he got convenience. But we don't know what the consumer is willing to do today in terms of conservation concerns as they relate to packaging. And that, basically, is what I would like to chat with you briefly about.

SYNPOSIS OF COMMENTS RE SLIDES

I am going to rely on some slides, from this point on, because my business really is visual and I feel much more comfortable in this medium rather than in the verbal aspects of communication. The title assigned to me originally was 'Designing from Beginning to End', but I am going to change that. Actually what we're talking about this morning is packaging and environmental protection and you have here today a very knowledgeable group of specialists who can give you all kinds of statistics and programs.

However, we are wondering will industry sell recycling. We're also wondering how we're going to handle the recycling if our cities are in extremely critical situations with respect to finances, and how they can handle and distribute wastes. We are concerned in many ways about the makeup of packaging.

I mentioned composite packaging a moment ago, and how in our business and in packaging development and design it became almost an expression of virtuosity in the 1960's to be able to use 7 laminates and different types of material in a package, because we were getting such tremendous technological breakthroughs in the packaging industry. Nevertheless, we still had the consumer out there -- looking, watching, confused, hearing a great deal, seeing a little, and he wanted in on the subject. So I want to talk about communications planning to the consumer, which I consider the missing link in environmental programs as well as the subject of packaging pollution.

We are concerned with the areas of communications planning as a company, just as we are with package design, with marketing and research, and this is not a commercial. I just wanted you to know that all of these tools have to be put to work somewhere along the line, if we're going to find out how much activism we can expect from the consumer with respect to packaging.

Now, we all are potential victims of the ecology, even those who act as designers and planners of aesthetic environments. In fact, I'm reminded that you have a very fine designer here in Columbus called Eugene Smith who, five years ago, put together a film on "Ugly America". At the same time we were working on another version of this subject, and took it on tour around the country.

At that time, we were thinking only about people, and we didn't worry so much about solid wastes. We were primarily concerned about visual environment, the aesthetics, the honky-tonk streets that we were creating in our municipalities, and our question was then, "Is business responsible for bad designs?" Is it the businessman who says, "Don't talk about aesthetics, I've got my eye on the bottom line, and profitability is all I am concerned with".

Today, our corporations are much more interested in their responsibilities with respect to ecological programs and, specifically, they're concerned with their communications posture with all of their publics on the subject, and we think we're going to see a great deal within the next year of consumer product companies trying to reach the consumer in their home with their concern about packaging and ecology. I will have a little more to say on that specifically as we look at more visuals, for package design and development certainly can contribute substantially to the challenge of solid waste disposal.

If we had a packaging "explosion" in the '60's when convenience packaging and composite packaging became the by-word, then maybe we should now be looking for a packaging "implosion" where we go back and use our talents to simplify our packaging and to simplify the materials that we use in developing them. We are concerned with a great many brands and these brands are being measured by the consumer, and also being measured by research. Here, for example, is a report by our research affiliate, the firm of Opatow Associates, and I'll read it for you.... "complaints about how packaging is raising prices have increased steadily in the past three years". This is a report of this year. "Complaints about storage and convenience seem to have decreased somewhat, or perhaps we're testing smaller packages. The voluntary comments about the problems of disposal, either in terms of bulk or in terms of environmental effects, have increased to the point where specific questions must now be included in many questionnaires to measure opinions related to these subjects."

Opatow Associates has been doing quite a bit of research for major consumer brands and this is their comment, and they specialize in packaging research, after looking over six months of research reports. The report goes on to say..."There are already evidences of growing consumer concern. At the same time, experts within the packaging industry and in government at all levels are in serious disagreement with respect to the methods for attacking packaging pollution. This tends to confuse and frustrate the consumer who wants to make a contribution. In the final analysis, if it continues, it will probably fractionate and dissipate programs which are already proliferating from many sources and at many levels."

You all know that consumer campaigns are increasing very rapidly in which industries within the total packaging industry are trying to express their concern about ecology and, of course, they use it to further their marketing efforts. In the '60's, raw material suppliers and packaging suppliers were in fierce competition for the convenience package. We're distressed if, in the final analysis, advertising will be used to set up the same competition on so serious a subject as ecology and packaging pollution. We are even starting to see, and I counted six of them the past month, ecology symbols and identification devices being used by individual industries, and if these are proliferated it can only result in confusing and frustrating the consumer.

I have been challenged at a half dozen conferences about quotations or facts I've cited from public sources on paper fiber and the savings of trees, and I know that it is a very complex subject. But when it suits some companies, and I am not picking on St. Regis, believe me, because this same type of advertising is used quite a bit in the paper industry now, they go all out to tell consumers about the savings made possible by recycling. Yet, in conferences such as this one, there is little agreement, particularly in terms of the paper industry, that this accomplishes much with our present reforestation methods.

The Resource Recovery Act of 1970 includes seven major areas of activity, and I am sure most of you are familiar with them. The Environmental Protection Agency in its Solid Wastes Office is sponsoring a wide variety of long and short-term studies to evaluate the most promising approaches to these problems. These were spelled out at considerable length at the National Packaging Show in Chicago last week. But as far as we know, there is no research being done with the consumer to develop effective communications programs, so they can understand the problem better, and so they can choose from their options in contributing towards cleaning up the solid wastes problem.

For example, what is the level of consumer concern with respect to packaging pollution? How does it affect brand loyalty? What kind of programs might channel these concerns into constructive action? What kind of communications approach will best meet these concerns?

We know that newspapers are (this slide happens to be only for New York City, incidentally) the biggest problem in our waste disposal systems, but we don't see anybody doing anything to help the consumer get rid of them easily. Even handling them is often terribly difficult, and we wonder why self-liquidated premiums aren't offered so that people can somehow just physically handle or segregate ten issues of the New York Times. It's quite a job, if you've ever tried it.

We think that a lot more will have to be done to make it easier for the housewife and easier for her family to segregate and start the recycling process. For if segregation doesn't begin in the home, or maybe even in the retail distribution channels, local government agencies are left with the massive problem of disposing of these materials and, from everything that I have heard, to build the kind of incineration plants that we might need will probably take ten years -- and perhaps more tax money than we have available.

It doesn't require an expert to go into any supermarket, any drugstore, and quickly go down the line and see places where packaging material can be saved, and see places where the problem of ultimate recycling by reclamation could be simplified. But no matter what starting point you pick you hurt somebody.

Consider, just for a moment, gift packaging of liquor. How many of us would be willing to buy the bottle as it stands on the shelf? 40% of the liquor sold in the U.S. is sold during the holiday season, and we have contributed by developing quite a few designs for holiday liquor packaging. And every year it becomes more of a challenge to use more composite materials, to use more aluminum, to use more ribbons, even to put plastic symbols attached to the outside carton. Just in this area alone there could be a tremendous savings in packaging materials and a saving in solid wastes.

For ten years I've been kidded by the steel industry because we once made a recommendation for rounded, square cans rather than round cans. It would slow down the manufacturing process slightly and require some mandrels, but other than that, consider the fantastic saving in materials... about 20% in the ends alone, because you don't cut away so much waste as you do in a circle...about 18% less in corrugated cartons to contain the cans...about 12% saving in linear shelf space in the supermarket which the retailer would like. I am only using these figures as examples of all the areas that a non-expert could look at in order to save materials, because if you save package materials you reduce solid wastes.

Five years ago I judged a packaging competition, and we gave the grand award of the show to a Kroger orange juice container in a poly-pouch. Since the orange concentrate is a solid in a frozen form, it doesn't need the protection that some of the other packages afforded. It was interesting to me that this package, while apparently it was functional, economical, and everything else, was totally rejected by the consumer in test markets. Think of the saving if we went to concentrated syrups, or added our own water or soda in the home; or to collapsible boxes, with all kinds of ways to crease them and design them so that they can be more easily compacted.

We have found that in some of the research we've been doing that one of the real problems is the sheer bulk of packaging and the difficulty the consumer or the housewife has in compacting them in order to cut down the bulk of the solid waste that has to be carried out in trash. We have so many packages today that are really multi-packs of individual packages. Look at some of your soap packaging where the soap is wrapped in aluminum foil, then put in a carton, the carton is put together with 9 other cartons, then it is wrapped in poly, and marketed as a deal in a multiple package. The same is true of cereals. There are great opportunities in these areas to cut down.

Some years ago in working in the flour and sugar field, we found out that in flour over 80% of the housewives put the flour in their own storage container in the home. Yet we still have expensive flour containers, composites of plastic, foil, and fiber, and the same thing very often in the area of condiments and spices and herbs. These could also be put into very inexpensive pouches which then could be placed in the container in the home.

Do you remember the packages that the astronauts used in their weightless trips? Actually, ten years ago the

Quartermaster Corps in Chicago proved the feasibility of retorting process fruits and vegetables in plastic pouches rather than in cans, so it is a long way from that to getting them into the supermarket and understanding how to handle them. But this is just an idea for babyfoods, because if the babyfoods could be retorted in a mylar pouch then it also would cut down tremendously on material's waste and cost, and it might also make it much easier to dispense.

I said one of my major concerns is this question of communicating to the consumer, and before that is the concern about what will the consumer do if they get such a program? Suppose that the consumer were shown how they could contribute to solid waste disposal in packaging. How much will they actually do? I think that those are two of the most important questions in a lot of the technical and very specific discussions that we go through in this type of conference.

For example, suppose that we were able to flag a product and identify the type of packaging material to the consumer at the point of purchase. Then the consumer would have the option of purchasing packages which would contribute to the ecology. Suppose that we use, and this is very hypothetical and quite schematic, a blue square for metal packaging and a green circle for glass and a red triangle for paperboard containers, folding cartons, and so forth. And suppose that standards were established so that the manufacturer would be entitled to use these symbols if they met very minimum standards such as a minimum amount of recycled materials in the packaging, etc. Then the consumer could go to the supermarket shelf and start to make up his or her mind about how important the whole question of packaging and solid waste is to them. They would have the option at that point to do something about it.

Now suppose we went a step further and, of course, the supermarket would have signs in the store indicating that packages with these symbols on them did meet minimum standards for recycling and reclamation, and here was the program and this is what we would do about it. Then, instead of one huge shopping bag, whether you buy 3 packs of gum or 20 packages of cereal, you are given three different sized bags designed to deal with the volume of metal containers, glass containers, and dry groceries, and each one of them is coded so that at the checkout counter, as you came around, the segregation process was already started.

All this is a way of motivating and educating and bringing this process up to a level of consciousness and awareness where the consumer starts to carry out the cycle himself, which would mean that, right here in the supermarket, your metals would be separated from your glass and your dry groceries and folding cartons would also be separated. Hopefully, this process would continue on into the home, which might mean new designs for our trash containers, etc., but we would segregate as the products were used and the packages were discarded.

And then we would have to help in various other areas. For example, why not offer as a self-liquidating premium a can compressor, or compactor, at $1.98. I am not trying to put Whirlpool out of business, but we would design the cans with prestressed lines so that they would compact easily, and a child could do it. This only calls for the same torque that you might remember on the old-fashioned orange juice squeezers.

Suppose that instead of deposits on bottles we put a deposit on well-built, returnable, plastic carrying cases, because one of the problems in getting the glass back is how to carry it. After you would return the containers that you buy the product in, the glass would be disposed of in suitable bins at the supermarket parking lot.

We also believe that, whether or not any communications system is set up, the companies who are marketing the brands will have enough concern about the consumer's reaction to the ecology that they will cooperate. And so at the supermarket parking lot there would be disposal bins, and this could be dramatized through signs on the road signalling where disposal sites are set up. Maybe we could even keep our beaches clean by having a similar system of disposal bins providing for three different types of materials at the food service areas and other key locations.

Well, some will say that any program regardless of source builds an awareness of pollution problems and stimulates consumer education activity. We hear this a lot, but we think it's wrong. We think that a Tower-of-Babel approach to such a serious subject makes an ultimate unified effort on a national scale difficult if not impossible. The dangers are that this kind of confusion and frustration can lead to arbitrary legislation. It may also stimulate commercial exploitation of environmental activities and this is already in evidence. And it may delay worthwhile solutions coming out of competition among elements of the packaging industry, which now tends to put the blame elsewhere and thus operate against the coordinated national program.

In concluding, I have just these few points to leave with you. First, that consumer research is necessary to determine the levels of concern. Secondly, that a communications program industry-wide by the packaging industry should be undertaken to educate and motivate the consumer. Third, centralize and coordinate the consumer communications program nationally which might be done in EPA. Fourth, an effective visual and verbal identification program starts with basic principles and policies. Establish liaison for the communications program with manufacturing and distribution levels of the packaging industry to provide leadership and encourage cooperation. Fifth, feed the results of technical studies into the national communications program to ensure most meaningful activities at the local level. Sixth, and my last point, design and develop a program based on consumer research to simplify and standardize packaging using marketing criteria.

I am sorry that I ran to the full length of my time, Mr. Chairman, thank you very much.

# # #

PACKAGING FOR FOOD SYSTEMS OF THE FUTURE

Norman A. Vanasse
General Foods Corporation

Good morning ladies and gentlemen.

It's a pleasure to be here today. I appreciate this opportunity to speak and the chance to participate in the Solid Waste Conference program.

So far, we have heard from some distinguished representatives of industry and government. In the next day-and-a-half I'm sure we'll hear many equally stimulating and informative presentations.

This morning, I would like to talk about the demands of Food Systems of the Future on Packaging and their relation to effective solid waste management.

We'll look at these packaging demands from three points of view -- that of the consumer, the distributor and the ecologist. Following this, I would like to review current thinking on interim and long-range solution of the solid waste problem.

To begin, then, let's take a broad-brush look at tomorrow's food consumer and her world.

The consumer of the 1970's and 1980's

will by-and-large be the youngest, best educated and most affluent in history.

By 1975 it is estimated that more than 17 million Americans will be college graduates. And also by that year, more than half the population 25 years and over will have high school diplomas.

The time is soon approaching when more than half the nation will be 30 years of age or less. And this trend toward a more youthful society is expected to continue.

Nearly half the women in the United States between 18 and 65 are gainfully employed -- daily supplementing their household income.

The next two decades will see more consumer discretionary income than ever before -- resulting both from growing affluence and increased entry by the housewife into the job market.

Younger, richer and better educated -- tomorrow's food buyer will present a whole new ball game for the food industry and the food packaging.

A major way in which these changes will

Individuality will be still another characteristic of tomorrow's food buyer. Put another way, the housewife of the future will feel an increasing need to accentuate herself as distinguished from others -- to be an individual.

This individuality is expected to express itself through increased consumer style and color consciousness -- leading to an acceptance and demand for decorative, stylized packaging.

Both the products and packages she buys will be expected to contribute to her sense of individuality and self-actualization.

The meals and snacks tomorrow's housewife serves the family and friends will be expected to enhance her self image of individualism and creativity.

Interacting with these consumer attitudes will be what sociologists call a lower frustration tolerance.

Put more simply, tomorrow's food buyer will be much less patient with circumstances and situations which frustrate her intentions.

Convenience in terms of easy product availability and variety will become increasingly important to the consumer. Equally vital will be product convenience in terms of easy preparation and storage.

Tomorrow's wife and mother simply won't have the time or inclination to engage in difficult or time-consuming meal preparation.

And I think with productivity per man-hour increasing everywhere else, the housewife is correct in demanding equal freedom from drudgery.

So this is a brief look at tomorrow's convenience food consumer.

Educated and affluent, she reflects the permissiveness of a youth-oriented society. Venturesome and individualistic, her attentions have turned to the new and the different in order to accomplish self-actualization.

And of primary concern to the food industry and food packaging, she demands all these gratifications through less effort and inconvenience than ever before.

For us in the food industry, meeting the demands and expectations of this future food buyer will call for a number of shifts in emphasis.

As the tastes of both her and her family grow more sophisticated, the demand for more single-portion packaging will certainly arise. Father may demand French-cut string beans with his pot roast while brother and sister see southern-style cream corn as the only acceptable companion.

One family member may have a pressing social engagement at the dinner hour -- demanding an individual hot snack in place of the programmed evening fare.

In fact, we see a definite trend away from the traditional three square family meals and toward more odd-hour snacks and eating on-the-run.

Our consumer and her family won't confine their venturesomeness and other new attitudes to eating. The whole life style will be one of individualism.

This world of the future will also demand much in the way of package aesthetics and product information.

Already, the need for attractive packaging is making itself felt throughout the industry. In the future, packaging aesthetics will play an even greater role.

Of equal importance will be the information provided on the package. Already, federal state and local laws require detailed information in many areas. Still further information -- for example, caloric and nutritional values -- are voluntarily provided.

In the future, the demand for package information can only rise. Tomorrow's sophisticated consumer will want to know as much as possible about her intended purchase.

What is it? -- How will it look? -- How do I make it? -- and is it good for us? -- these will all be prime buyer considerations, facts the consumer will expect the package to supply.

To keep pace with the consumer's lowering frustration tolerance, future packaging will have to lend itself to more and more convenience.

Easy open; easy close; easy storage; easy disposal -- all these factors will be prime considerations in package design.

In some cases, the package will come to play an even greater role in actual food consumption than today. Eating utensils, for example, may be an integral part of the package or even the product itself. We will also see more packages serving as the actual eating cup, bowl or plate.

This, then, is a look at the future consumer and the packaging that will serve her.

Now, let's look at the food distribution systems of the future and their impact on packaging.

A prime consideration in examining future distribution trends are some rather dramatic projections for transportation costs.

Trucking costs are expected to rise 40 percent above the inflation index by 1981. Rail costs, on the other hand, have a forecast increase of 30 percent during the same time period.

To put it short and sweet, it's going to cost a lot more to move anything anywhere in tomorrow's world.

What does this mean for the packager?

One trend will certainly be toward more compact and lighter packages -- even if a possible rate base change from weight to volume should occur.

How individual packages fit together into cases and on pallets will also be a prime consideration. Wasted space can only mean wasted money, and more money than ever before.

Compact, light-weight and damage-free packaging will be required as the competition for store shelf space becomes more intense.

Today, the average grocery store carries approximately 8,000 separate items. In the next 10 years, however, we estimate a 57 percent increase in the number of dry grocery products alone. With frozen foods and the like, we look for a 125 percent increase in individual products.

Excess bulk and difficult handling simply will not be possible in this highly competitive market situation. And packaging will be called upon to play an increasing role in their elimination.

One area of conflict between these distribution trends and ecological concern is the severe limitations placed on the concept of returnable containers. As stores become more crowded and transportation rates rise, the economics of returnables will become increasingly prohibitive.

Turning to the ecologist and his view of future packaging, I'm sure he must shudder at the ramifications of much of what I've said so far.

Though certain aspects of this consumer and food distribution world I've outlined lend themselves to ecological concerns, many others combine to paint an initially bleak picture in terms of environmental protection.

By 1976, for example, it is estimated that more than 73 million tons of packaging materials will be used annually in the United States -- that's more than 661 pounds for each man, woman and child.

Going further, one expert has predicted that this annual per capita level could reach 900 pounds by the dawn of the 21st Century.

Though we've all heard similar projections a hundred times, I never cease to be awed by the magnitude of such figures.

From a purely ecological point of view, it could be said that all packaging should be reduced to a bare minimum. A purist in this field could easily demand a return to the most basic in packaging technique -- promising doomsday as the only alternative.

But to assume that housewives should buy cereal in 20 pound bags or their beef by the side is as absurd as to say that ecological considerations should be totally ignored.

And I don't feel that sensible ecologists see a return to a world devoid of convenience as the answer, anyway. I think they see the solution much as most of us do -- as a balanced approach combining the stronger points of each position.

Speaking for society, the ecologist

makes it perfectly clear that a concentrated environmental protection effort in all areas is the mandate of the future.

He recognizes consumer demands in packaging and other areas but warns that these very buyers could be buried in the results of their own quest for convenience.

A statement of the varying conflicts among the future demands of the food consumer, distributor and the ecologist is not a new theme by any means.

It does, however, merit periodic examination since it is fundamental to the dilemma facing the food packaging industry and society as a whole.

It is a realistic assumption that modern food packaging helps allow many women the free time to leave home and participate in environmental protection activities.

The farm wife of 100 years ago felt fortunate if able to attend even a monthly social event. And even these were often devoted to food preparation -- for example, corn husking.

But today's woman usually has a social agenda rivaling a movie star -- and often with a family and a job to boot. And packaging -- food and otherwise -- has made a major contribution to this emancipation.

However, the very same housewife that demands the ultimate in packaging convenience is -- either directly or as part of society -- demanding effective and total solid waste control.

So the obvious question arises -- can society have all the convenience and other packaging attributes demanded by its future course while still progressing toward total environmental protection?

Put another way -- can the consumer and society have their cake and eat it too?

To me, the answer is a definite YES.

I feel that the same technology that produced our present and potential states of the art in packaging can -- through a systems approach -- provide effective solid waste management.

Through innovation, cooperation and plain hard work, society can and will have all that it desires in each area.

The dynamics of a free economy dictate that the food industry strive to meet all consumer demands -- packaging and otherwise. Failure to do so -- regardless of how noble the reason -- would prove economic suicide.

Certainly, government could regulate packaging to an extent where all consumer desires and convenience went by the way side. But such dangerous overreaction could cripple our free market system beyond the point of no return.

We recognize that sensible legislators and administrators seek to work within the parameters of the free enterprise system in order to reach solutions.

Functioning in a free economy, we at General Foods see our ultimate mission as that of providing the consumer of tomorrow with all the convenience, freshness, aesthetics and other attributes she desires.

With us -- as I'm sure with most companies -- this is the name of the game.

But we also feel that this can and must be accomplished hand-in-hand with a definite contribution to the systems approach to solid waste management I mentioned earlier.

No one point along the road from a package's inception to its ultimate disposal can be singled out as totally responsible for the solid waste problem. Any workable solution must come from an integrated effort at all points -- each engineered to facilitate the other.

This conference, incidentally, is typical of the ways in which this solution will be found. Only through meaningful communication and cooperation can a systematized effort be formulated and effected.

Effective communication to the public at large is also vital. And today, public awareness of the packaging industry's environmental concern has never been greater.

Paramount in creating this increased

public understanding have been several dramatic reclamation efforts -- each combining economic and social incentives for container collection.

But I'm sure I speak for the entire packaging industry in saying that in the long view, such measures are at best a stop gap.

The ultimate solution -- all authorities agree -- lies in mass recycling. For maximum effectiveness, the only answer can be total municipal recycling plants -- plants able to sort mixed garbage and retrieve useful materials and energy without a pollution problem.

Time does not permit a discussion of the economics and methods involved in such plants. But the experts insist that such systems can be operated -- and operated at a profit.

All of us, I'm sure, recognize that this network of recycling plants supported by a totally sympathetic packaging technology won't spring out of the blue tomorrow, next month or even next year.

Therefore, all of us -- government and industry -- must also seek interim solutions in addition to long range ones.

To do otherwise would be like building vertical takeoff airports while neglecting fixed wing airports because someday jets might be obsolete.

The food industry and its packaging elements must act now to ease the load on current incineration, landfill and other solid waste disposal operations.

At present, this is being accomplished in several ways -- primarily through the reduction of bulk, weight, and overall packaging excesses. We are also constantly looking at new packaging materials -- materials which lend themselves to compaction and pollution-free burning.

And, interestingly enough, we are finding that many of these changes actually add to -- rather than detract from -- consumer product acceptance.

This development poses an interesting question -- one which we could all keep in mind as this conference moves from the overview to the specifics of technological exchange.

The question is -- where are the best ways to mutually serve the best interests of the consumer and the environment? Where, through technology and innovation, can we give society the best from all possible worlds.

In closing, let me again emphasize the need for an integrated systems approach to effective solid waste management. The only solutions will be those that account for all the variables -- consumer demand, distribution economics, technological capabilities and ecological necessity.

I hope my sketch of tomorrow's packaging for tomorrow's foods has given you a further insight into some of these variables.

I also hope I have shown how consumer demand interacts in many varied ways with the viewpoints of the distributor and the ecologist toward packaging.

I feel the food industry is highly aware of the need for corrective action on the solid waste problem -- both in the interim and over the long haul.

And not only are they aware of the problem but have and will continue to make significant contributions to its solution.

Thank you for your kind attention. Again, let me say it has been both a pleasure and an honor to speak here today.

Thank you.

SESSION II

PLASTICS, COMPOSITES AND PAPER

Chairman:

J. H. Lindholm, Chief
Paper, Packaging and
Graphic Arts Economics
Columbus Laboratories
Battelle Memorial Institute

INCENTIVES FOR THE RECYCLING AND REUSE OF PLASTICS

Jack Milgrom
Arthur D. Little Inc.

We have just completed a study for the U.S. Environmental Protection Agency to explore incentives for the recycling and/or reuse of plastics. This is the first of the so-called incentive studies that include not only the gathering of information, but an attempt to find solutions.

But why select plastics for this study? Plastics represents less than 2%, on the average, of the solid waste stream. However, in addition to being very much in the public's eye today, plastics belong to that category of materials whose physical properties are often degraded during recycling, and essentially none is being recycled from the consumer. On the other hand, materials such as metals, glass, and paper are being recycled today, and the recycling of these materials will no doubt increase; therefore, the concentration of plastics in solid wastes could become more significant.

There were two aspects to this study: (1) to develop a descriptive model of the plastics cycle, and during the study we interviewed all segments of the plastic cycle from resin producer to supermarket; and (2) to develop complete strategies for promoting the recycling and reuse of plastics. At present, we will present some of the information that we gathered, but will withhold information related to overall strategies until the government agency has fully reviewed our recommendations. However, we have cautioned our client that in the development of strategies relating to plastic materials, significant action cannot be taken unless the strategies include all competitive materials.

In carrying out this study, it was important to define certain terms that are used by the industry and develop new ones. The words reuse and recycle, for example, are often used interchangeably. Reuse indicates that the package is used over again in its same form. The returnable bottle is an excellent example. On the other hand, recycling implies that the packaging material is reprocessed, which in the case of plastics means remelted and reformed, either into its original form as in primary recycling, or into another plastic form as in secondary recycling. Thus, plastics can be pyrolyzed to yield non-plastic materials such as oils, waxes, and greases. Considering economic value, reuse offers the highest return, and pyrolysis and energy conversion the lowest.

We have also developed a new term called NP or nuisance plastics. These are the plastics of no value, and they are usually found in the disposal area. A corrollary term, SP or scrap plastics, is plastic that has potential value. It is equal to SP_V (scrap plastic of value) + NP. In other words, if the scrap plastic cannot be used, it becomes NP.

Because this study was limited to recycling, only thermoplastics were considered. Thermoplastics can be melted and reformed numerous times in contrast to thermosets that only can be melted and formed once. As shown in Table 1, thermoplastics represent 80% of all plastics. Recycling coatings and adhesives (not including extrusion coatings) is virtually impossible. Thus, excluding these still leaves 75% of all plastics as potentially recycleable material. Our study has only included the "Big 5" thermoplastics, namely, high and low density polyethylenes, polypropylene, polystyrene, and PVC. These account for 89% of the potentially recycleable plastics.

Early in our study, we developed seven objectives or criteria for assessing alternative strategies. These also served to guide us in our information gathering phase. These objectives are listed in Table 2. I would like to comment on two of them. The first objective, which is the prime one, refers to environmental damage. There are two aspects to this damage--an economic aspect and an aesthetic one. One example of economic damage is that caused by burning plastics in facilities not specifically designed for this operation. Another example, which is probably more significant, is caused by the high bulk density of uncrushed rigid plastic containers. This can cause difficulties in disposal from the garbage can to the collector and ultimately in the final disposal area. Assorted plastic packaging that is not compressed occupies as much as 800 cu ft/ton, in contrast to the approximately 30 cu ft/ton density of the completely compressed plastic material.

The aesthetic aspect is essentially a subjective term, and the best example is litter. For example, consider the following two plastic packaging items as litter--a piece of transparent plastic film and a large, opaque, rigid plastic container. The latter is obviously the most visible and, therefore, most people would consider it aesthetically displeasing. However, the same container sitting in one's backyard is considered less damaging to the environment than the container along the roadside, which illustrates the importance of the degree of exposure.

I would also like to comment on Objective No. 7. Plastic packaging can be either mono- or multi-plastic, that is based on more than one plastic material, and they also can be composites. A composite is a product consisting of one or more plastics together with a non-plastic substrate. As many of you know, the technical problems of reprocessing multiplastics or composites makes this approach unattractive. Reprocessing or recycling requires the plastic to be homogeneous: one plastic type with minimal contamination.

We mentioned earlier that plastics represent less than 2% of the solid wastes. Accordingly, the technical and economic problems of recovering these materials from the final disposal site are overwhelming. This suggests that any attempt to recover scrap plastic from the consumer of necessity would have to be done by intercepting it before it reaches the final disposal area. Therefore, collectability should be considered. Again, let us consider plastic film and containers. Normally the household consumer considers plastic film in the same way as paper wrapping and discards it in the trash can. In contrast, the rigid container is often set aside. It is easily segregated from the household refuse, and in the past, containers were set aside for return to the store.

Let us now look at the entire plastics cycle shown in Figure 1. The resin producer is responsible for determining the chemistry of the plastic product. The fabricator takes the granulated or pelletized resin and transforms it into a shaped article. The converter then uses the fabricated items such as film to make, for example, plastic bags. Both of these sectors are responsible for producing the end plastic item. The manufacturer/packager segment, and in particular the packager, is the major decision-maker in the packaging cycle. He is the one who decides just what type of plastic package he wishes to use for his product.

As one proceeds from resin producer to packager and on to the consumer, one goes from the very large companies to the smaller ones. Geographically, resin producers in the U.S. are relatively concentrated, particularly along the Gulf Coast; whereas, the wholesaler/retailer sector and obviously the consumers are distributed according to population density.

Note by the dashed line that all segments of the plastic cycle, including the consumer, generate NP. Thus, there are two major sources of NP, that from the industrial sector and that from the consumer. Some are not aware that plastics today are being extensively recycled. For example, as an integral part of their operation, fabricators usually recycle between 10 and 15% of their production. This amounts to more than 1.5 billion lbs. In addition, the resin producers sell SP that they themselves cannot use through the reprocessor segment. This is a small segment of the industry today. Nevertheless, approximately 1 billion lbs. of scrap plastic went this route in 1970. The reprocessor purchases scrap plastic and converts it to secondary resin.

We have prepared flow diagrams for each of the segments of the plastic cycle. That for the resin producer is shown in Figure 2. The decision points are represented by the triangles and are listed in Table 3. The pentagonal symbol represents various categories of NP. In our report we have prepared a rather complete catalogue of sources of NP generated by the various segments in the plastic cycle. Note that NP can be generated during every operation. This diagram illustrates how scrap plastic can be removed in three different ways: (1) by recycling it in ones own facilities; (2) by selling it to a reprocessor; or (3) by removing it as NP. Another important aspect illustrated by this diagram is the production of "offgrade" resin. If the resin producer does not meet the specifications designated by his customer, or if he has to dispose of transitional material produced as he changes from grade to grade, the product is called virgin off-grade resin, in contrast to virgin prime resin. Now if market conditions are such that the resin producer cannot sell all of his products, he stores it and then sells it to the highest paying customer. In times of low demand he often sells this surplus as offgrade material. This procedure provides the resin prices. Incidentally, 1970 was a year where most of these resins were produced in oversupply, and the resin producer is currently attempting to use this safety-valve technique.

Now let us turn to the consumer's segment. The consumer really does not consume most products, he merely uses them for a certain period of time. This time corresponds to the service life of a given product. Thus, a plastic product in the hands of the consumer only becomes NP when it is of little value to him.

A summary of the estimated service lives of different plastic products is shown in Table 4. The products listed in Table 4-A are the most significant ones for this study. Note that the production losses are included. The values listed in Table 4 were used to estimate the volume of different plastic products in the disposal area.

Let us next examine the types of NP in the disposal area today and as we estimate to 1980 (see Figure 3). Not surprisingly the major component is that derived from packaging, corresponding to about 60% of all NP in the disposal area. Accordingly, the development of strategies focused on these two types of NP can solve the major problems of plastics in the solid waste stream. Notice that housewares, which is the third category, only represents about 6% of the total NP.

Most other types of NP are present in small fractions and would be difficult to recycle because many are present as composites.

The statistics used to prepare the graph in Figure 3 are shown in Table 5. Based on the Big 5 thermoplastics, 6.5 billion pounds of NP were estimated to be in the disposable area in 1970. By 1980, we expect this to rise to 18.8 billion pounds.

Packaging wastes, which are almost 4 billion pounds today, will rise to approximately 10 billion pounds by 1980. This represents a decrease in the percent packaging waste as a percent of all plastics in the disposal area. Other plastic items with long service lives, for example wire and cable, will account for more and more of the NP during the coming decade; and it is this factor which will reduce the percent packaging waste. However, these estimates do not include the potential increase in NP, if plastic beverage containers become a reality. We do not believe that this will occur to any large extent before 1975, but by 1980 the penetration of the market could yield as much as 2 billion pounds of NP, if recycling and reuse does not become a viable solution. Thus, packaging wastes in 1980 could be 12 billion pounds.

Table 6 shows the composition of NP according to the type of plastics in the disposal area. Polyolefins which includes polyethylenes and polypropylenes, are the major type of plastic in the disposal area today. It represents about 70% of NP from all sources, but that from packaging accounts for

82%. PVC from all sources of NP accounts for about 12%, while that from packaging is only 6%.

Many are surprised to discover the large volume of NP produced by industry, but wastes from each segment are cumulative. Though the resin producer produces as little as 1% NP, this is added to the larger waste generated by the fabricating and converting operations. Table 7 shows the various sources of industrial NP; fabrication and converting account for the major portion, and are approximately 60%.

The total amount of industrial NP is about 1 billion pounds. The major plastics in industrial NP are LDPE and PVC, as shown in Table 8. The relatively large concentration of PVC is more difficult to process and reprocess than the other major thermoplastics. We do not forsee any major changes in the composition of industrial wastes during this decade. Looking at packaging NP from the consumer sector, according to form, almost 90 weight percent of all packaging is monoplastic (see Table 9). Thus, most of this packaging is potentially recycleable. Though the rigid containers account for approximately 40 weight percent of all plastic packaging wastes, on a volume basis rigid containers are the major type of plastic packaging wastes. Looking ahead to 1980, we do not see any major changes in the composition of packaging wastes by form. Although the production of composite and multiplastic film will increase, rigid mono-plastic containers will still account for the major portion of packaging wastes on a volume basis.

Because plastic bottles are potentially the most easily collectable and, therefore, recycleable wastes, let us examine the type of bottles in the disposal area today and in this decade, as shown in Table 10. Most plastic bottles today are fabricated from one plastic--high density polyethylene. They accounted for 84% of all plastic bottles in the disposal area in 1970 and this percentage could rise to 88% by 1980. Fortunately, only two major grades of high-density polyethylene are used for bottles today. Thus, if one could collect bottles such as those used for milk, bleach, and detergents, collection and separation could go hand in hand. The plastic bottle, therefore, which can be considered the most damaging to the environment, as explained earlier, is fortunately the most collectable and potentially the most recycleable.

In conclusion, let us examine the major impediments to recycling plastics. The key one is economics. Secondary resins compete with off-grade virgin resins. Ten years ago, in 1961, the difference in price between these two for a typical film application was 3¢/lb. Today it is virtually zero, or certainly no more than 1¢. Thus, instead of narrowing the gap, our strategies have been aimed at widening the gap between these competitive materials.

Another important impediment is the political one. As all of you know, governments often work at cross purposes. For example, many government specifications insist upon the use of virgin material, instead of developing specifications based on performance. To give another interesting example, we have noted that the U. S. State Department in their AID program has removed secondary plastics from their approved list. Thus, foreign manufacturers are unable to receive favorable financing from the US on purchase of these secondary materials. Incidentally, these items were only removed during 1970.

Another impediment is the psychological one. The general usage of the terms virgin and secondary material suggest to the consumer that the secondary product is inferior. This a common impediment whether the product is a plastic or a textile.

Finally, and certainly not last, is the technical impediments. As mentioned earlier, plastics must be homogeneously one material, free of foreign contamination. Otherwise, they are not easily recycled.

Looking at plastic wastes as a resource, we believe that some plastic containers are reuseable, for a number are being reused in the packaging of milk today. Others are potentially recycleable, and we believe that schemes can be developed to promote their easy collection.

TABLE 1. PLASTICS PRODUCTION--1969[a]

Type	Pounds (Billion)	% of Total Plastics
All plastics	18.7	100
Thermoplastics	14.9	80
Thermosets	3.7	20
Thermoplastic coatings	0.8	4
Big 5 thermoplastics (excluding coatings)[b]	12.5	67
Thermoplastics (excluding coatings)	14.1	75

(a) Source: U. S. Tariff Commission

(b) HDPE, LDPE, Polypropylene, Polystyrene, PVC. Extrusion coatings are included in this category.

TABLE 2.

1. Minimize environmental damage.

2. Maximize pound-volume of troublesome nuisance plastics (NP) recycled and/ or reused as a percentage of total plastic production.

3. Minimize pound-volume yield of troublesome nuisance plastics as a percentage of total plastics production.

4. Minimize the sum cost of achieving Objectives No. 1, 2, and 3.

5. Minimize economic disruption.

6. Minimize disposal costs consistent with the objective of minimizing environmental damage.

7. Maximize the recycleability of plastics with regard to their ease of collection and their ease or reprocessing.

TABLE 3. DECISIONS

1. Additives Required?
2. Colorants Required?
3. Within Specifications?
4. Sell to Fabricator?
5. Can Waste Plastic be Recycled in Own Facilities?
6. Can Waste Plastic by Sold to Reprocessor?
7. Sell to Compounder?

TABLE 4. ELAPSED TIME FOR PLASTIC PRODUCTS TO REACH DISPOSAL AREA

Product	Estimated Life (Years)
A. Elapsed Time 0-5 Years	
Production Loss[(a)]	0
Packaging	1
Novelties	1
Photographic Film	1
Disposables (Dinnerware, hospital goods)	1
Construction Film	2
Footware	2
Apparel	4
Household Goods	5
Toys	5
Jewelry	5
B. Elapsed Time 6-10 Years	
Sporting Goods (Recreation, boats)	7
Automotive	10
Phonograph Records	10
Luggage	10
Appliances	10
Furniture	10
Cameras	10
C. Elapsed Time 11-30 Years	
Wire and Cable	15
Business Machines	15
Miscellaneous Electrical Equipment	15
Hardware	15
Instruments	15
Magnetic Tape	15
Construction	25

(a) During production, compounding, fabrication, and converting the resin and manufacturing the plastic items

TABLE 5. NUISANCE PLASTICS IN THE DISPOSAL AREA[a]

Type of Product	1970 Million lb	1970 wt %	1975 Million lb	1975 wt %	1980 Million lb	1980 wt %
Packaging	3925	60.1	6445	56.2	10,170	54.0
Footwear	90	1.4	140	1.2	190	1.0
Records	95	1.4	140	1.2	205	1.1
C and A Film[b]	130	2.0	195	1.7	285	1.5
Industrial Wastes	1000	15.3	1830	15.9	3,050	16.2
Toys	310	4.7	555	4.8	945	5.0
Transportation	90	1.4	250	2.2	470	2.5
Appliances	100	1.5	230	2.0	440	2.3
Furniture	60	0.9	170	1.5	355	1.9
Wire and Cable	40	0.6	95	0.8	480	2.5
Novelties, Disposables	100	1.5	200	1.7	400	2.1
Others[c]	120	1.8	230	2.0	430	2.3
Housewares	425	6.5	885	7.7	1,270	6.7
Construction	50	0.8	100	0.9	150	0.8
TOTAL	6535		11465		18,840	

(a) Source: A. D. Little

(b) Construction and Agriculture

(c) Includes business machines, instruments, luggage, sporting goods, apparel.

TABLE 6. PLASTICS IN THE DISPOSAL AREA IN 1970 ACCORDING TO TYPE OF PLASTICS[(a)]

Type of Plastics	From Packaging[(b)] Million lb	wt %	From all Sources[(c)] Million lb	wt %
Polyolefins	3240	82.6	4231	70.6
Styrene polymers	445	11.3	1006	16.8
PVC	240	6.1	775	12.6
TOTAL	3925		5992	

(a) Source: A. D. Little

(b) Includes cups, refuse and household bags

(c) Does not include business machine, instruments, luggage, sporting goods, novelties, disposables, construction

TABLE 7

SOURCES OF INDUSTRIAL NP
(1970)[a]

Operation	Million lb	wt %
Polymerization	200	20.0
Compounding/Reprocessing	100	10.0
Fabrication	310	31.0
Converting	260	26.0
Other[b]	130	13.0
TOTAL	1000	

(a) Source: A. D. Little

(b) Wastes generated in distributing products from manufacturer/packager to consumer.

TABLE 8

INDUSTRIAL WASTES (NP)[a]

Type of Plastic	1970		1975		1980	
	Million lb	wt %	Million lb	wt %	Million lb	wt %
HDPE	76	7.5	159	8.6	292	9.5
LDPE	336	33.6	619	33.8	1,040	34.1
Polypropylene	65	6.5	155	8.5	312	10.2
Styrene polymers	204	20.4	359	19.6	577	18.9
PVC	321	32.0	538	29.8	828	27.1
TOTAL	1,002		1,830		3,049	

(a) Source: A. D. Little

TABLE 9. TYPES OF PLASTIC PACKAGING

Type of Packaging		Consumption (Billion pounds)	wt %
Physical form	Composition		
Film	Monoplastic	1.84	46.8
Film	Polyplastic	.31	7.9
Rigid	Monoplastic	1.54	39.2
Rigid	Composite	0.24	6.1

TABLE 10. PLASTIC BOTTLES IN THE DISPOSAL AREA[a]

Type of Plastic	Million lb	wt %	Million lb	wt %	Million	wt %
HDPE	524	84.0	920	87.0	1409	87.9
LDPE	32	5.1	35	3.2	40	2.5
Polypropylene	10	1.6	12	1.1	15	0.9
PVD	58	9.3	92	8.7	140	8.7
TOTAL	624		1059		1604	

(a) Source: A. D. Little

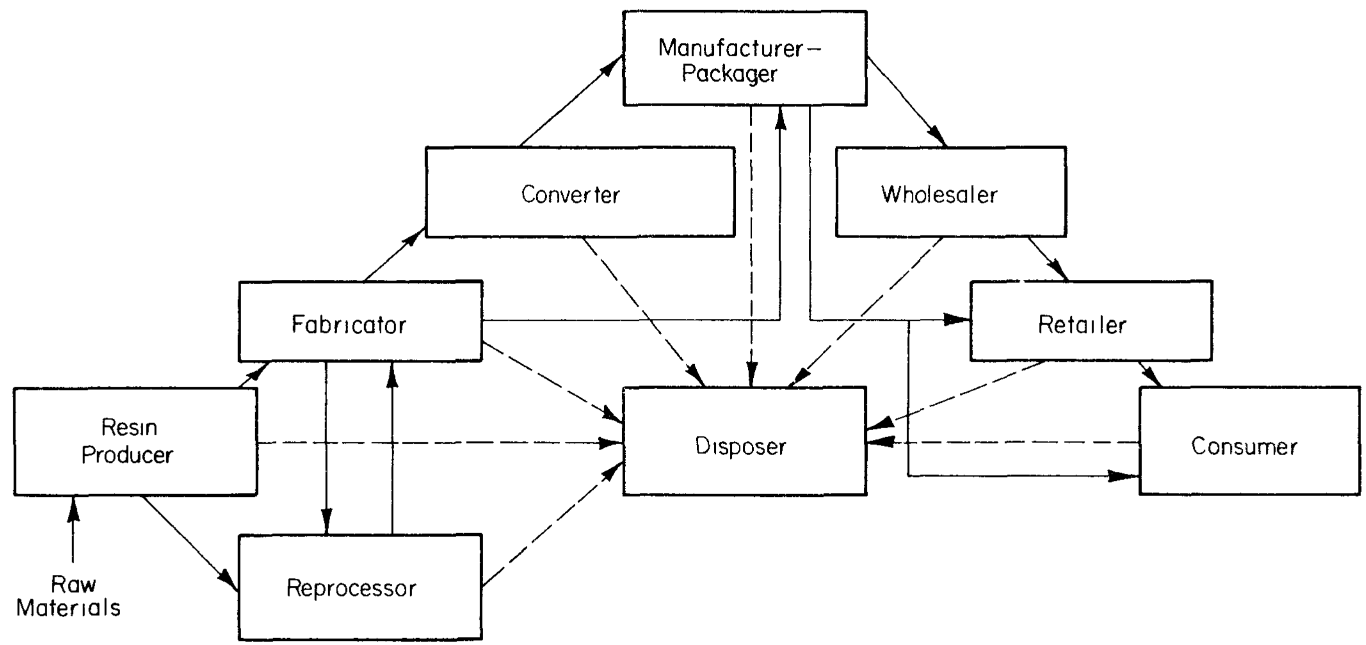


FIGURE 1. PLASTICS CYCLE

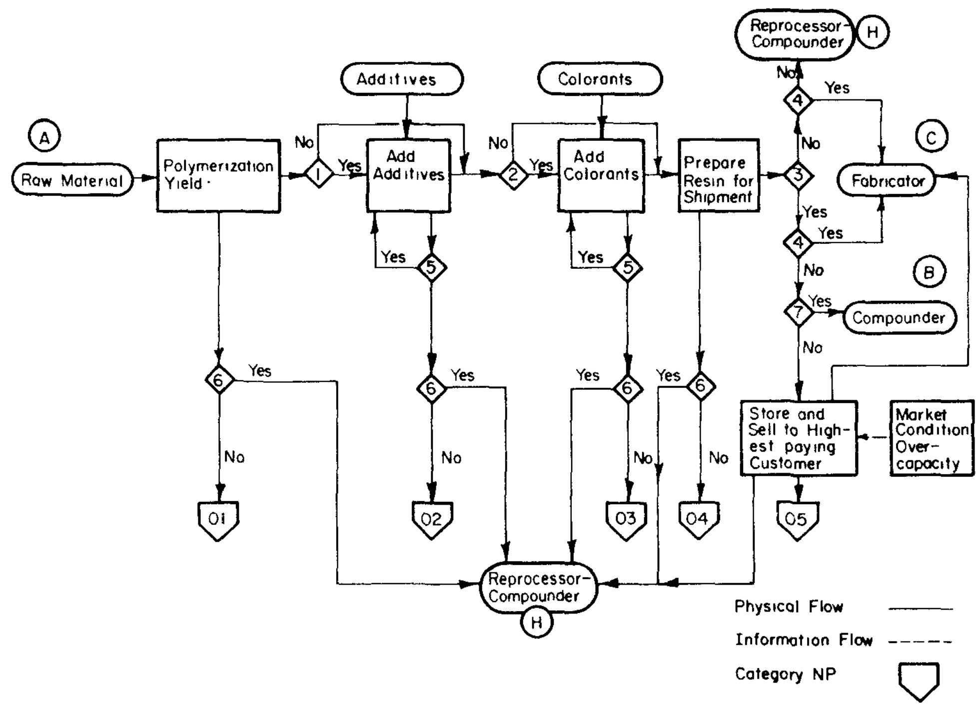


FIGURE 2. RESIN PRODUCER

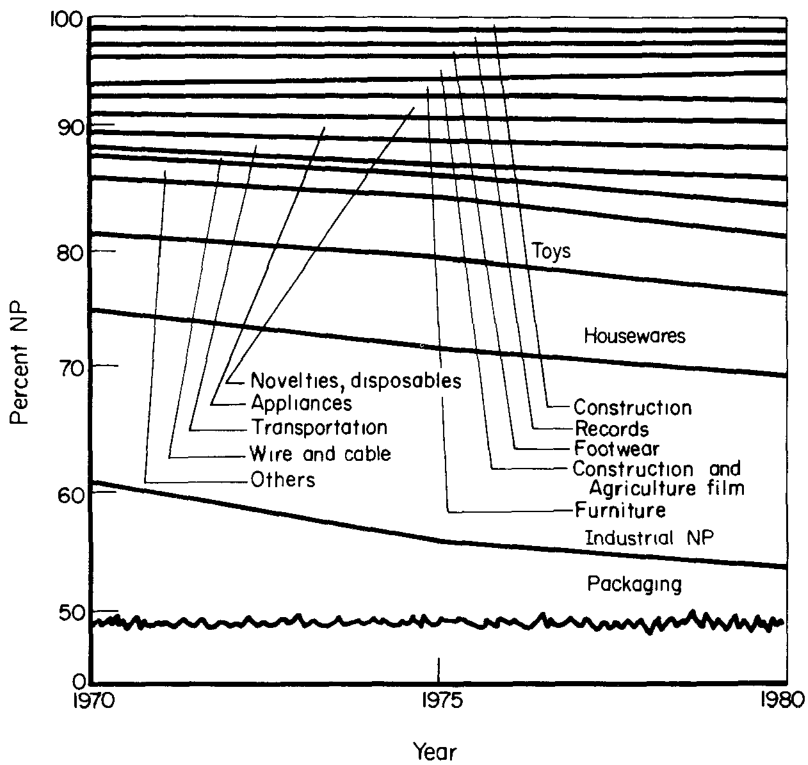


FIGURE 3. PLASTICS IN THE DISPOSAL AREA
(Source: A. D. Little)

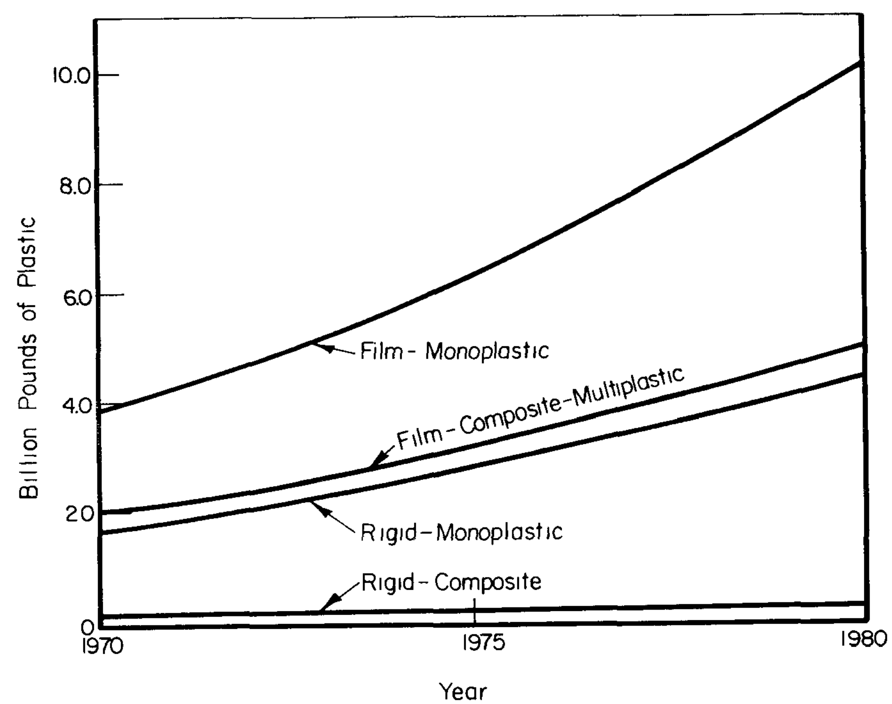


FIGURE 4. PACKAGING WASTES

THERMOPLASTICS IN WASTE RECYCLING

K. L. Burgess
The Dow Chemical Company

Plastics are a diverse group of materials, and each product family offers unique properties that enable it to fulfil certain market needs. Essentially all plastics are derived from petroleum, and are carbonaceous matter. In recycle we can consider plastics to be either hydrocarbons, with energy values, or engineered molecules with reusable physical properties.

A thermoplastic material, by definition, is one that softens and flows when heated. This means that thermoplastics can be recycled repeatedly. The fact that polyethylene, polystyrene, and polyvinyl chloride are "reworkable" has been long understood in the plastics industry. Plastics fabricators rework their scrap with little concern that a significant percentage of the polymer is subjected to multiple passes through the fabrication process.

Since it is well established that thermoplastics are easily reworkable, it is pertinent to ask the question, "Why do we have a plastics waste recycle problem?" The answer is a complex description of technical, distribution, marketing, emotional and consumer problems. One way to look at these problems is to compare the nature of the scrap plastic found in the fabricators plant to the plastic solid waste as generated by the consumer.

The fabricator has his waste located at the fabrication site; avoiding costly collection or freight. He has a fairly constant supply in terms of both quality and quantity and since a trip through the extruder will not significantly change the prime product, the scrap is easily mixed with prime material with no change in process or article properties. He has control of the handling of the waste to insure that it is clean and that different plastics are not mixed. His scrap is the same specific type, grade, and color of material as the prime material he is using.

The major key to the fabricator reuse of scrap is the fact that different polymers are scrupulously kept separate. In general, plastics do not mix with each other to form useful alloys. For example, polystyrene in polyethylene or in polyvinyl chloride will result in a two phase system that will have properties less than the properties of the individual components. This is true of almost all mixtures of the major plastic materials. Since any material will obviously be sold on the basis of the property balance for a given market, heterogenous blends of scrap generally have less value than the components parts.

It is also obvious that the final product must have properties to fit some application or it will have no value at all.

Thermoplastic property values can be recovered from the scrap essentially in two ways. The first requires isolation of a pure plastic component. The second requires finding a "compatibilizer" that will improve the properties of an article made from mixed plastics.

The Dow Chemical Company has been involved in reclaimation projects involving both isolation and modification. One utilized pure polyethylene which went from fabricator to consumer and back to recycle without dilution with the other polymers. The second project is a research program to develop a compatibilizer for plastic mixtures. Thus, we have some experience in both of the preferred choices for solution to the problem.

In order to isolate a pure plastic component from collected solid wastes, we would first have to separate plastics from the other wastes, then further separate the collected plastic into the individual types and grades. This would involve very significant costs. Therefore, if possible, it is more desirable to keep the material from getting into the waste streams in the first place.

The Golden Arrow Dairy experiment in San Diego has received considerable attention and is an example of avoiding the solid waste stream. The dairy and its Vice-President, Don Calori, deserve a considerable vote of thanks from the Plastics Industry for engaging in the breakthrough experiment and sharing their experience with us. The Dow Chemical Company has not contributed directly to this project, but as a resin supplier to the dairy we have been involved in discussions on equipment, methods and markets for recycled or reclaimed plastic.

Golden Arrow markets milk in disposable HDPE containers. They observed the ecology concern of their customers and decided to do something about it. A project was set up to have the used bottles picked up by the regular delivery man and returned to the dairy. A significant volume of a single type and grade of plastic was available at one point with very little cost incurred in the collection. A grinder was installed to reduce the bottles to a saleable and shippable flake and a market was found for the flake. This sounds very simple but no part of the project has really been that easy. A relatively large percentage of the home delivery bottles are returned but 5% of the returns are contaminated in such a way that they cannot be recycled. This means that each bottle has to be inspected before being ground and the added labor cost is significant. Some contamination occurs even with this inspection. Another restriction is that the bulk density of the flake is not high, so it cannot be shipped large distances without added freight cost. Cartons for the flake do not present a problem in this situation but they could add cost if the grinder did not have readily available used containers.

A market for the ground PE has proven to be the largest obstacle. It was determined because of health laws that recycle could not go back into milk bottles or other food packages. The earliest, and most publicized market, was a plastic drainage tile. Government specifications required virgin polymer for that use so the outlet was temporarily lost although the cost and properties were attractive. The dairy has found other customers but their path has not been easy. This is probably to be expected in a real breakthrough project but I think we have learned a few things.

This type of recycle is a waste management problem. Going from the consumer to the collector without contamination is not easy and finding uses for the scrap, even though the properties are good, will be very dependent on economics. Virgin plastics are relatively inexpensive. Rehandling, container, shipping and marketing costs can easily put the price of scrap at a level that is unattractive relative to virgin material. These problems can be solved but since some of them are local in nature, it will take good management and good marketing on the part of local distributors. Technical problems, such as quality control, are inversely proportional to the degree of consumer interest in making such a program work. The other problems such as government regulations and customer trust can be worked out with time and conscientious effort.

Since pure plastic components are not readily available, development of compatibilizing agents is desirable. Last October at the Society of Plastics Engineers Regional Technical Conference in New Jersey, J. N. Schramm of The Dow Chemical Company, reported on the use of chlorinated polyethylene as a compatibilizer for mixed plastic scrap. This development is unique because, as stated earlier, plastics do not normally mix to give useful products. The scientific reasons for incompatibility of plastics and why an experimental approach is necessary are worth some explanation. The mixing of liquids, which is one way of describing amorphous polymers, has been well studied for small molecules. Solubility can readily be defined with the usual free energy formula:

$$\Delta F = \Delta H - T\Delta S$$

If the free energy of mixing is favorable, the materials are soluble. The same is true of large molecules but all of the emperical rules that we have built up for small molecule mixing fail for polymers. The entropy change for small molecules is small and fairly constant, therefore the enthalpy (useable heat content) determines the solubility and all of our rules are built around this simplification of the free energy equation. With large molecules, the entropy change is significant and variable, therefore the simplified solubility rules do not hold. Like dissolving like, solubility parameter, and the clichés of solution technology are worthless. The limited study of the solubility of large molecular solutes in large molecule solvents has proven these facts but has not systematically demonstrated a set of entropy rules similar to the common enthalpy rules.

If solid materials are mutually insoluble, they can still be combined to give useful products if they can be made to adhere. Laminates and aggregates are well known as heterogenous materials that are useful as long as the phases have some degree of intermolecular bonding; adhesion. The major polymers, polystyrene, polyethylene and polyvinyl chloride do not have capabilities for hydrogen bonding and they have very limited polarity, therefore very small Van der Waal forces. Because of these molecular limits, they demonstrate very low adhesion and do not form useful laminates without special treatment or special compatibilizers.

Schramm's report at the RETEC noted that chlorinated polyethylene (CPE) has the unique property of mixing with most polymers and the capability of "gluing" together a composite made of the polymers found in the normal waste stream. Table 1 illustrates the properties obtained from such a blend. Note that the tensile impact increases significantly even though the tensile strength does not. This is exactly what would be expected from increasing the interphase adhesion of a heterogenous mass. The scrap used in these experiments has the composition noted in Table 2.

Other data obtained by using mixtures of pure polymers are shown in Table 3 and 4.

Significant quantities of CPE must be used and properties are going to vary with the nature of the scrap. Within certain limits, the end product properties can be varied by the inclusion of some virgin product. The end use of such a product will have to depend on local marketing possibilities and local scrap composition. It is doubtful if a centralized research effort can give more than general guidelines as to uses. The final success of a program to utilize scrap by this method will again depend on the ability of local distributors and formulators to solve local problems. Tile, plastic pallets, certain toys and many other applications are possible outlets.

Other methods of recycle are being investigated and discussed. Many of these recognize the difficulty of increasing the value of scrap and tend to utilize it as something other than a thermoplastic. One company has made a light weight concrete that is said to have good properties. Compressed building blocks are said to be feasible when the right combination of plastic scrap is mixed with other waste. A form of recycle that must not be omitted is the use of plastic waste as a fuel. Petroleum is the starting raw material for all of the major polymers and the chemical changes that we perform do not greatly reduce the BTU content. PVC does have a lower BTU/lb. than does petroleum but based on carbon content all of the major polymers are nearly equivalent to the fuel from which they were derived.

In summary, I think that several points should be repeated. Waste thermoplastic articles can be recycled into a second generation of fabricated articles. This can be accomplished by reprocessing a single type of polymer, or by compatibilizing the mixed plastic from the waste stream. The problems associated with the recycle of a single type of polymer are primarily waste management and marketing. Technology problems still exist before compatibilized blends can be perfected but again marketing is a real obstacle in this approach to recycle. Plastics do have recycle value as fuels or fillers although such recycle does not take advantage of the physical properties built into the polymer molecule. Some of the recycle problems have been identified and solutions, or at least leads to solutions, have been found.

Why do we have a plastic waste recycle

problem? We know that recycle is technically feasible. In the past the economics and the quantity of plastics in the waste stream have not warranted the development of methods for collection, separation, distribution or marketing. The programs described in this discussion indicate that the economic climate may now be right for the beginning of a new phase in the plastics story, but this must be proven "case by case" at the local level.

K. L. Burgess
4/21/71

TABLE 1

PHYSICAL PROPERTIES OF ACTUAL PLASTICS SCRAP WITH INCREASING LEVELS OF CPE 42/2/4 COMPRESSION MOLDED SAMPLES

	Elongation (%)	Tensile (psi)	Tensile Imp. (ft. lbs./in.2)
100% Scrap Plastic Mix	11	1450	0
15% CPE/85% Scrap Plastic Mix	11.7	1715	0.45
17.5% CPE/ 82.5% Scrap Plastic Mix	12.7	1690	0.54
20% CPE/80% Scrap Plastic Mix	15.7	1715	0.76
22.5% CPE/ 77.5% Scrap Plastic Mix	17.7	1712	1.5
25% CPE/75% Scrap Plastic Mix	20	1600	1.6
27.5% CPE/ 72.5% Scrap Plastic Mix	22	1600	2.83

TABLE 2

COMPOSITION OF SCRAP PLASTIC*

LDPE approximately	44%
HDPE approximately	19%
Polystyrene approximately	31%
PVC-ABS-PP approximately	6%

*Plastics in total were less than 4% of the waste.

TABLE 3

PHYSICAL PROPERTIES OF SIMULATED SCRAP

	Tensile Impact (ft.lbs./in.2)	100% Modulus	Elongation (%)	Ultimate Tensile (psi)
Mixture A	0	0	10%	1960
Plus 15% CPE	0	0	15%	1790
Plus 33% CPE	2.6	0	50%	1500
Plus 50% CPE	10.7	925	415%	964

Mixture A = LDPE/HDPE/PVC/PS (25% each)

TABLE 4

PHYSICAL PROPERTIES OF SIMULATED SCRAP

	Tensile Impact (ft.lbs./in.^{2})	100% Modulus	Elongation (%)	Ultimate Tensile (psi)
Mixture B	0	0	60%	1650
Plus 15% CPE	2.29	0	98%	1530
Plus 33% CPE	6.08	0	115%	1100
Plus 50% CPE	14.1	862	278%	940

Mixture B = 50% LDPE/25% HDPE/12.5% PVC & PS

POLYTRIP®, THE RETURNABLE PLASTIC MILK BOTTLE SYSTEM

Karl H. Emich
U. S. Industrial Chemicals Company

We in this country as well as a good deal of the world are faced with the fact that pollution of air, water, and land has reached proportions that are enormous. The demand for correction is justified, but some impatient voices want a change over night without realizing what gigantic problems must be solved to achieve this goal. A number of these problems require the development of new technologies before they can be successfully attacked.

Hand in hand with these problems goes the the one we are concerned with at this conference: the disposal of solid waste. One portion thereof deals with waste created by the food packaging industry. Competition and the intent to focus the customer's attention on the package as a selling point have created a multitude of packaging shapes and forms from a wide variety of materials.

The effective, yet efficient disposal of solid waste generated in the U. S. has become a social and economic problem. While we are only at the beginning of this battle it seems that a number of methods offer possibilities to help bring about a satisfactory solution.

I would like to present to you one solution that U. S. Industrial Chemicals Company, a division of National Distillers and Chemicals Corp., has to offer in the realm of liquid milk packaging. It is known under the trade name of Polytrip® Systems and consists of the returnable polyethylene milk container and an inspection device, a volatile organic contaminant detector.

In 1961 and 1962 several dairies experimented with single trip plastic gallon milk containers to test public acceptance. These early tests showed encouraging results and dairies expanded their efforts to commercial status. In 1963 there were just 4 dairies packaging milk in plastic, by 1964 there were 65; in 1965 - 135; 1966 over 500; and by 1967 over 700 dairies throughout the country were using plastic milk bottles.[(1)]

The polyethylene bottle has a number of advantages over its competitors, the glass bottle and the polyethylene extrusion coated paper container:

it is light weight;
it is tougher and less breakable;
its translucency gives milk a rich, creamy appearance;
it has excellent appearance; and, it can be designed in many appealing shapes.

In 1966 there appeared in the dairy market a new development which offered the dairy operator the advantages of plastic containers combined with cost efficiencies exceeding those of the glass bottle. This was the returnable polyethylene milk bottle system.

The basic problem previously prohibiting the use of the plastic bottle on a returnable basis was its tendency to absorb hydrocarbon contaminants. If the consumer had been using this bottle for the storage of hydrocarbon based chemicals, no dairy washer could remove the so induced contamination from the container. The consumption of milk packaged in contaminated containers could produce health problems. Since dairies could not predict the customer's reuse of the returnable bottle before its return for refilling, there was an evident need for a device that was able to detect hydrocarbon contaminants, such as those contained in gasoline, kerosine, paint thinner, etc.

The successful development of the detector was the result of a long and carefully researched project which started in early 1963 in Spokane, Washington. It was tested by the City of Spokane Health Department, the U. S. Public Health Service (USPHS) and Washington State University.

Only when these groups were satisfied that the detector provided an effective safeguard against such contaminants did the USPHS judge that the system met applicable provisions of the Public Health Service Grade "A" Pasteurized Milk Ordinance.

Further development of this instrument was necessary to keep pace with the steadily increasing bottling rates in the dairies. While the first instruments were only capable of testing 20 bottles per minute, the present detectors can handle about 130 bottles per minute.

The detector is located between the bottle washer and the filler directly over the conveyor line. As a bottle passes underneath, a sample of air is taken from it. A flame ionization detection system determines the total amount of hydrocarbons present in the sample. If the analysis shows a contaminant level which is of public health significance, a punch mechanism is actuated which renders the bottle unuseable.

The needed hydrogen for the flame is produced inside the detector cabinet. A built-in test mechanism allows checking of the proper sensitivity level at any time. Interlocks are provided to shut the bottle washer or the conveyor line down should the instrument malfunction. U.S.I. maintains a complete service organization throughout the United States to prevent costly downtime in the dairies and to install newly purchased units.

The Polytrip® returnable plastic milk bottle is blow molded of high density polyethylene and is especially designed for reuse. At about 170 grams for gallon bottles and 126 grams for half gallons, the strong walls and sturdy construction eliminate container collapses at the filling line and let them stand up for more than 100 trips. Half gallon and one gallon sizes with blown or Glass Container Manufacturer's Institute (GCMI) finishes are now available to the industry.

The Polytrip® bottle is annealed to insure that it does remain constant in volume after repeated washes in the dairy.

The type of resin used for the returnable container must meet Food and Drug Administration (FDA) requirements in the Federal Register, Subpart F, Section 121.2501 for food packaging applications. Furthermore it must meet the 1965 recommendations of the USPHS for single service and multiuse milk containers, as stated in the Grade "A" Pasteurized Milk Ordinance. As for the milk bottle, some states require approval of the Department of Health and the Department of Agriculture. Most accept the findings of the USPHS regional office in their area. Some require approval of even small local and municipal boards of health in addition to the state agencies. There are no known requirements for milk bottle resins as stipulated by the National Bureau of Standards (NBS).

Milk volume in linear polyethylene bottles can qualify as a prepackaged commodity which meets the requirements in Handbook 67 of NBS.

Only polyethylene resins of high density are suitable for use as fluid milk containers. Presently used resins have 90-95% crystallinity and 0.965 g/cm^3 density to maximize rigidity, surface hardness, permeation resistance, and surface friction resistance. Bottles with these properties withstand easily over 100 trips from dairy to customer and back.

To the dairy the advantages of this system are significant. The returnable polyethylene containers are practically unbreakable, which when compared with glass, greatly reduces production down-time and delivery losses. No breakage means a safer, cleaner, filling operation for the dairies. Easier handling and stacking in the plant result from the lighter weight of the bottle when compared with the other returnable container - glass.

Distribution by truck becomes more economical because of the light weight. Up to 20% more milk in polyethylene containers can be placed on a truck when compared with its main competitor glass.

From experience we have found that in places where the returnable milk bottle was introduced it was very well received by the consumers. The majority of dairies experienced an increase in volume output, in a number of instances very significant ones up to 100%.

And now let us take a closer look at how the returnable plastic milk bottle fits into ecological viewpoints. Compared with glass containers, the polyethylene returnable container outperforms it in the number of trips about 5 to 1. All other forms of containers, be it plastic or paper, are of the single trip variety and do not help to reduce the amount of solid waste. According to Public Health Service (PHS) publication 1855, packaging materials on a tonnage basis will increase at a rate of 3.6% annually in the 1966 to 1976 period. Expressed in pounds this means a change from 103.4 billion pounds in 1966 to 147.0 billion pounds in 1976.[2] These gigantic figures give an idea what is in store for us in the future.

One obvious way to reduce waste is the reduction of the quantity of packaging wastes generated. Reuse of the package is one way to achieve this goal. If we assume only 100 trips for the polyethylene returnable milk bottle we have 100 disposable bottles for each 1 polyethylene reusable container, or about 4 - 5 glass bottles for the same one polyethylene multitrip bottle. This shows a drastic reduction of waste generated.

But sooner or later the fact becomes clear that even these long lived containers must be disposed of. They then become a part of the plastic waste disposal problem. Recognizing this problem the Society of the Plastics Industry has undertaken two tasks:

1. an effort to help find solutions to solid waste problems, particularly the safe and efficient disposal of plastics, and,
2. a program of information and education on the role of plastics in solid waste.[3]

Our present methods of disposal need revisions or replacements by more efficient and appealing systems. Added consideration must be given to the fact that we need to recover more and more of the valuable raw materials to prevent the rapid depletion of our natural resources.

Open dumping, landfill, composting, and incineration are still the prevailing methods of disposing of solid wastes. Here is a quick look at them:

Open Dumping. This is still the most widely used method of waste disposal. More than 3/4 of all municipal refuse is discarded in dumps. This method has numerous drawbacks and its use is increasingly being banned.

Sanitary Landfill. This method has more positive features and, if properly done, is an excellent way of disposing waste. Polyethylene is well suited for this method because it does not decompose. However, desirable sites for landfill are becoming very scarce. Only about 10% of the country's refuse is disposed of in this way.

Composting. Although composting is another feasible method of disposal, in practice, it was found that only a very small market for composting is available with limited growth prospects. At present, only 1% of refuse goes into composts.

Incineration. Although not ideal, incineration is a practical means of disposing of many types of solid waste. Efficient incineration can result in a volume reduction of 12 to 1. Until better methods of disposing of solid waste are found, incineration seems to be the logical process. The reason that incineration has a bad name is, and I quote from the September 1970 Position Paper by The Society of the Plastics Industry: "because most incinerators are obsolete and inefficient, providing poor reduction of refuse and polluting the air. There are only about 300 municipal incinerators in the country and 75% of them are inadequate by Bureau of Solid Waste Management standards."(4)

Again and again voices have been heard protesting incineration of plastics because of the poisonous gases produced during this process. The truth is that emissions from burning polyethylene are no more and in many cases less toxic than those from other burning organic materials.

It would be ideal if polyethylene could be recycled. This way waste would be eliminated and raw materials could be saved. In reality recycling today is far from being feasible. Therefore we have to resort to the known methods of disposal mentioned earlier.

In the meantime we should try to find useful means for the disposition of plastic waste. In Europe, polyethylene waste is used to generate power. The Btu content is about the same as coal or three times the solid waste average. Addition of polyethylene to garbage aids the combustion in incinerators.

We are only at the beginning in the development of really effective methods of solids waste management. With our growing population we will be faced with increasing amounts of solid waste while on the other hand drastic changes are indicated to counteract the rapid depletion of some of our natural resources. It cannot be left to one group or another to take action, but industry, science, and government must work together to find solutions for the pending solid waste problems as well as for the preservation of our resources.

REFERENCES

Technical Papers

(1) Eder, Peter, "Plastic Containers, The Challenge," presented at American Management Association, Dairy Packaging Seminar, Chicago, Illinois (May 1967).

(3) The Society of The Plastics Industry, Inc., "The Plastics Industry And Solid Waste Management", Position Paper, (September 1970), p. 5.

(4) Ibid, pp. 7-8.

Books

(2) Darnay, A. J. Jr., and Franklin, W. E., The Role of Packaging In Solid Waste Management 1966 to 1976, Public Health Service Publication No. 1855, Washington D. C., U. S. Government Printing Office 1969, p. 99.

RECLAMATION OF PLASTIC-PAPER COMPOSITES

Safford W. McMyler
Riverside Paper Corporation

INTRODUCTION

The Riverside Paper Corporation in Appleton, Wisconsin, has for the past twelve years successfully operated a plant which removes adhesives, wax and plastic coatings from paper and paper board in order to recover the wood pulp fiber for use in the manufacture of fine papers in its paper mill.

This was commenced and continued so that the company, which had no captive source of manufactured wood pulp, could, through the substitution of these fibers reclaimed from waste, maintain a competitive position with those fine paper manufacturers which have integrated paper/pulp mills.

The economics of this process are proven to our satisfaction. A savings, which ranges between 15 and 30% below the commercial market price of pulp, has been realized for a number of years. This savings recognizes all of the processes required to produce fiber matching the characteristics of virgin fiber - the initial chemical process which I am here to describe, plus the cleaning and bleaching processes necessary for the high grades of business and school papers we manufacture.

But what has now become equally important as the economic benefits is the ecological benefits: There are some plastic film removal methods employed in recovering waste fiber - the mechanical or wet systems - which result in serious solid waste disposal or stream pollution problems; whereas our method is, in effect, a dry-cleaning process producing wood pulp fiber, essentially 100% free of the undesirable contaminant which is disposed of by utilization as fuel in our boiler. The reclaimed fibers are completely unimpaired in physical properties.

The original patent on this process was issued under U.S. Patent No. 3,058,871 on October 16, 1962.

Recent technical improvements in this process, known as the Polysolv Process, are covered by a patent application Serial No. 17,892 which was issued on March 9, 1970.

In Summary: This is a revolutionary method of waste fiber preparation by a non-polluting process.

Advantages of the Polysolv Process

1. It is a dry furnish process and the recovered fiber is in the same form as it entered the reactor.
2. The treatment of the waste paper and board at high temperature softens any wet strength resins present resulting in more efficient pulping of the reclaimed fiber.
3. The process is 100% efficient in removing polyethylene and wax coatings, and polyvinylacetate and other similar adhesives.
4. It is a closed system and there are no problems of air or stream pollution.
5. The exotic coatings can be mixed without discrimination.
6. On printed waste, if the ink is on the coating, solvent extraction dissolves the coating and simultaneously removes the ink leaving the reclaimed fiber essentially ink free.
7. Tests show no strength loss between solvent extracted and non-extracted fiber.

PROCESS DESCRIPTION

Basically, this simple, solvent extraction process can be described as consisting of three phases:

- Dissolving
- Solvent recovery, and
- Removal and utilization of the reclaimed contaminants.

The chemical processing equipment for the existing plant occupies about 4000 square feet on four floor levels.

The waste is delivered to our plant by rail in bales weighing approximately 1500 lbs.

Phase I - Dissolving - The Rotary Reactor is loaded with coated unused milk cartons, converter cuttings, or shredded large sheets. The reactor is then closed and the extraction cycles are carried out in three (3) stages using trichlorethylene, a common degreasing solvent.

The first extraction stage is made with the "dirtiest" solvent, i.e. solvent already used twice. The second extraction stage with solvent used once. The third extraction stage with clean solvent. After each stage, the solvent is simply syphoned out of the reactor; therefore, the extraction efficiency is rather low. During the charge, the solvent is instantaneously heated, in a heat exchanger, up to 240°F (boiling point of trichlorethylene is 188°F). In the reactor, the temperature drops to the neighborhood of 190-205°F. The vapor phase of the superheated solvent maintains an operating pressure in the reactor of approximately 15 psig. No steam is added to the reactor at this stage, but only to the solvent heat exchanger. After the last extraction, the solvent is syphoned to the semi-clean tank as thoroughly as possible. Steam is then fed to the reactor to strip the residual solvent from the fibers. This operation is carried out at 8-9 pounds in the reactor with available superheated steam and requires 60 to 90 minutes according to the amount of trichlorethylene remaining in the reactor. When the pressure in the reactor starts to drop, there is no more recoverable solvent. The steam supply is shut off and a light vacuum is applied to the reactor. All the solvent vapors from this final stripping operation are recovered in a separate water cooled condenser; the mixture of solvent and condensed steam is fed to a water separator. The clean solvent is pumped to the clean solvent tank. The furnish, now solvent and poly-free and only slightly moist because of the steam stripping operation, is dumped to subsequent equipment.

Phase II - Solvent Recovery - The dirty solvent recovered in the first stage of Phase I is fed batchwide to a conventional still with natural circulation heat exchanger, operating at 200-220°F and 6-9 pounds pressure. The vapors of solvent are condensed in a water cooled condenser with the condensation creating a vacuum of approximately 2-5 inches. The system is also provided with a refrigerated after-condenser and finisher still. The residual plastic which tends to remain as a sticky and jelly-like mass at the bottom of the still, is kept in a fluid condition with the introduction of No. 2 fuel oil making it easy to handle or pump.

Phase III - Disposal - After completion of the distillation in the finishing still, the removed wax or poly and fuel oil are dumped into a tank for incineration or injection into a plant boiler to reclaim the heat value of the fuel oil-poly mixture.

Figure I, is the entire process flow diagram.

The production capacity of this plant is now 12 to 14 tons per day of waste processed. We have long considered this capacity as hardly more than pilot sized. Last year, having analyzed the condition of the existing plant (then 12 years in use), the potential for expanded sources of raw material, and the economic return expected on an expanded capacity, we decided that the investment for a 50 ton per day capacity plant should be made as quickly as possible. This would satisfy all our needs for waste fiber in our existing paper products.

Subsequent to this decision such a plant became available, and it was purchased and dismantled and is being reinstalled at our mill in Appleton. Startup of this facility is scheduled, for July 1, 1971.

With this startup, Riverside paper Corporation will have completed the steps from experimental process, through successful pilot plant operation (at a rate of 14 tons per day for the past 3 years of continuous operation) to commercial plant production. It will provide 50% of the fibers required for our paper mill's total production.

We intend now to turn cur efforts toward extending the utility of the process to other materials and contaminants. Preliminary advanced research has already offered encouraging results on contaminants heretofore considered unassailable. With the shutdown of our old small plant, which we intend to leave intact, we will have a facility available for full-scale trials on waste materials which offer promise.

We are testing a program for collection of the plastic-paper composites from large and concentrated users such as schools and institutions.

Today, with the high degree of interest in recycling and environmental ecology being expressed by the public, government and industry, we are encouraged by the attention being given to our no pollution Polysolv Process.

HISTORY

A brief description of the background and development of our patented process:

In the early 1950's, Riverside Paper Corporation tried to use secondary fiber that was generated in the manufacture of juice and milk cartons. This fiber was white bleached board contaminated with polyvinylacetate (PVA), **other** similar adhesives, and also wax. The percentages of PVA and adhesives ranged up to 2% by weight, and wax up to 12%. All of this fiber was free from other contaminants such as ink.

When this secondary fiber was repulped, screened and used to make conventional writing grades of paper, the PVA would show up as yellow shiners in the sheet; the wax would cause excessive slip; and contaminant build-ups occured on paper machine dryers causing excessive downtime for clean-up. These repeated problems promoted extensive laboratory work, followed by a research program, which developed a solvent extraction process. This was followed by the construction in 1958 of a 24 ton per day operational plant.

After several years of successful operation, polyethylene slowly became a contaminant in the secondary fiber. A second research effort was conducted. This resulted in a modification of the process and a rebuild of the existing plant to remove polyethylene.

DEVELOPMENT

Early laboratory trials at removing these contaminants involved the use of caustic soda, wetting agents, soaps, de-inking formulas, and solvents. These cooking formulations were followed by a series of aqueous washings, screenings, flotations and centrifugal cleanings, all designed to wash out the waxes, and mechanically remove the agglomerated particles of PVA and adhesives. Although some of these trials were encouraging, when they were applied to large scale production and the secondary fiber used in manufacturing paper, the same problems of yellow shiners, excessive slip, and coating of the dryer surfaces reappeared. As a result these investigations were terminated.

In 1955, a review of patent literature and published material encouraged the approach toward continuous hydrocarbon solvent extraction. With the use of a large laboratory extraction apparatus, a series of trials was run evaluating different solvents to remove the PVA and wax. All of these extractions proved to be successful. This prompted the construction of a pilot plant designed to treat the waste paper board trimmings on a continuous basis, since at this time batch processing was thought to be uneconomical. The initial solvent (of several tried) was carbon tetrachloride, but because of deficiencies in the pilot plant, the solvent losses were high. This resulted in high toxicity and undesirable economics. Battelle Memorial Institute was then engaged to investigate the idea and in October, 1956, their studies concluded that "the solvent extraction of waste paper probably would be feasible with commercial equipment." The Riverside Pilot Plant was then disassembled and transferred to Columbus, Ohio for more intensive work. As a result of Riverside's preliminary work and the studies by Battelle, several conclusions were reached:

1. The Riverside process was both technically and economically feasible.
2. The process lent itself better to batch than continuous operation.
3. Battelle's experiments developed a very effective means of recovering the solvent.
4. The waste contained several types of adhesives such as PVA and in some cases considerably more than had been realized.

As a result, it was decided that Riverside would build a new Pilot Plant in Appleton employing a batch process and the new recovery phase. It was this pilot plant that prompted the decision to proceed with design and construction of a 24-ton-per-day commercial solvent extraction plant.

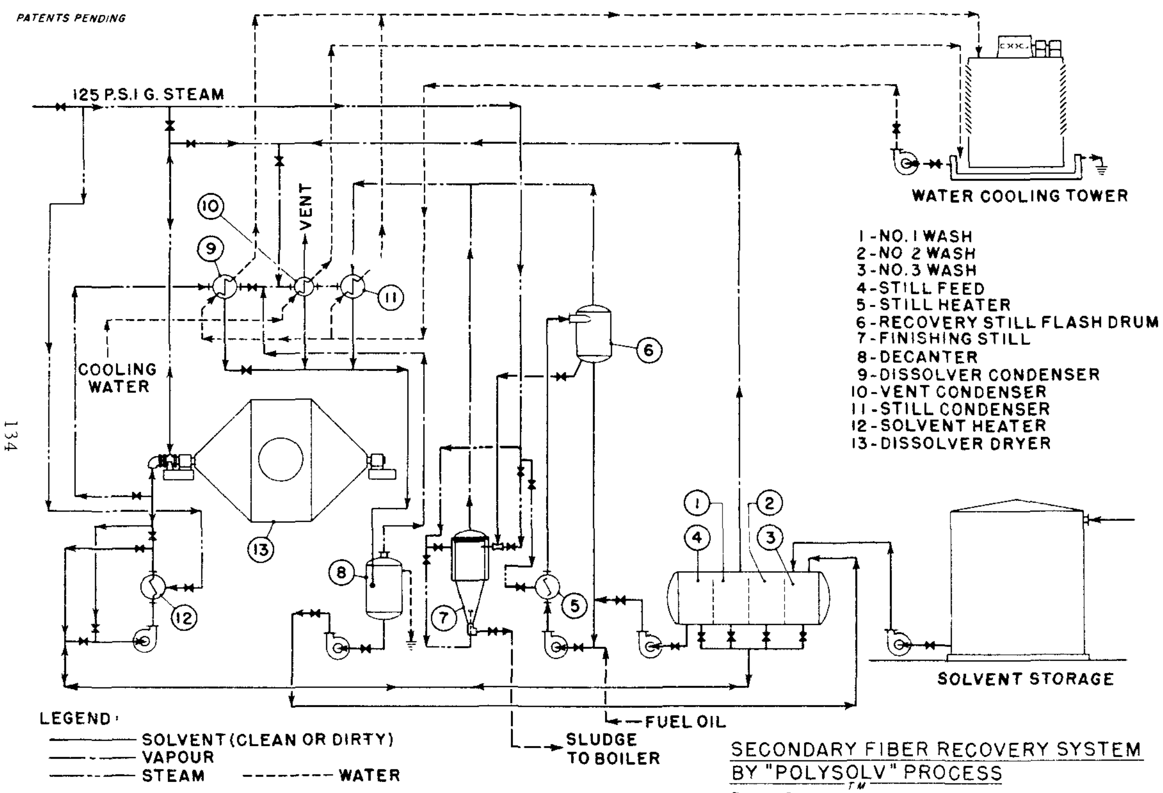
Upon start-up of this solvent extraction plant, no major problems were encountered and the plant's performance exceeded expectations. However, the availability of the small (ink-free) carton punchings was not as expected. This forced the plant to use printed milk cartons, set-up wax cartons, and any other wax carton stock that was available. These types of broke were not considered in the design of the plant, but with minor adjustments, these were also reclaimed. This created a new and unexpected problem -- disposing of the tons of contaminated wax removed in the process. This was resolved when a buyer was found for the reclaimed wax.

After several years, polyethylene coated pieces slowly began showing up in the baled waste and concern was felt regarding the future availability of raw material. The Battelle Memorial Institute was again consulted. Their research report revealed that it was feasible to extract polyethylene from board and paper under the proper conditions, using the existing solvent, but that the recovery of spent solvent and polyethylene would have to be investigated in the full scale plant.

Therefore, another pilot plant was constructed. It confirmed the Battelle opinions.

The operating plant was then rebuilt and upon start-up one glaring problem resulted: The dissolved poly plugged the evaporator in the distillation process. This was not completely resolved until a later date, but was temporarily solved by saving all wax waste and blending this with poly coated waste in the extraction phase. When the solvent was then reclaimed in the distillation process, the distillate or waste did not plug the operation and recovery could be carried out at lower temperatures. This was practiced until waxed waste became increasingly scarce and almost non-existent. It was then determined that No. 2 fuel oil could be utilized as the catalyst. The patent was modified to include this development.

The plant capacity, when rebuilt for the new operating conditions, was reduced to 12 to 14 tons per day. Even at this output, the very favorable economic advantages mentioned earlier are enjoyed.



SECONDARY FIBER RECOVERY SYSTEM BY "POLYSOLV"™ PROCESS

The Black Clawson Company

Shartle Division Paper Mill Stock Preparation Systems
Middletown Ohio 45042 Phone 513) 422 4561

Fig. I

PAPER INDUSTRY PLANS

Judd H. Alexander
American Can Company

In San Francisco, there is a solid waste transfer station which serves the whole peninsula. Standing near the head of the dumping pit, a visitor can watch the wastes produced by two million people being plowed toward the loading chutes. An occasional can is visible in this vast quantity of material, and bottles, orange peels, and telephone poles. But, the overwhelming impression is of paper. The garbage is made of paper--50% by weight and nearly 70% by bulk.

Yet, a conference of this nature devotes half days to plastics, metals, and glass and a half hour to paper containers. Does this suggest the solution to the paper in our waste is near at hand? There is an obvious answer to the problem, so obvious that advice on the subject is available from nearly every concerned club woman and schoolboy: recycle, recycle the paper to solve the solid waste problem; and, as a bonus, every ton of recycled paper will save 17 trees. That is a good, simple answer, but it may not be adequate for this terribly complex problem.

Before talking about designing containers for recycling or reuse, it might be well to explore the potential, the limitations, and the economics of recycled paper today.

But, first, one misconception should be discussed. Recycling paper does not necessarily "save trees." Save them for what--for rotting in the forest? Trees die; and it makes sense to crop them at the peak of their maturity and to replace them with fresh growth. A young forest will produce about triple the oxygen of a mature forest. Do not think of pulpwood trees as the spreading chestnut in front of the smithy, the charter oak, or the graceful elms around the village square. Pulpwood trees are grown as a crop--some, in our Southeast, are harvested as soon as 13 years after planting. Forest management and tree genetics have increased the yields so that, in spite of increased harvesting, our nation is a net gainer on trees--the United States grows more trees and more board feet of timber each year than is cut.

During World War II, we recycled 35% of all our paper. By 1970, the amount recycled had dropped to 19%. But, percentages can be misleading, particularly when discussing a commodity whose usage is increasing rapidly. Note these two facts:

1. In 1970, we recycled about 60% more paper than we did in 1944.
2. If we increase the recycling percentages to World War II levels by 1985, as suggested by the National Academy of Sciences, we will still have 60% more paper in our wastes then than we have today.

Perhaps we have not done such a terrible job in the past. Perhaps recycling is not the whole answer in the future.

What happened since World War II to cut that recycling percentage so drastically? The answer lies in technology, consumer preference, and economics--mostly economics.

The wastepaper markets have always been subject to violent price swings. To meet their growth requirements, the paper companies turned to virgin fiber as a more stable and dependable supply source.

At the same time, the potential sources for virgin fiber expanded considerably. We noted that 19% of paper is made from recycled paper, but another 26% is now made from other wastes which were not utilized 25 years ago. I am thinking of sawdust, chips, slabs, and other lumber mill waste which were formerly burned in the wigwam burners so familiar in the West.

New pulping techniques brought in many new species of trees as prime fiber sources: aspen, cull hardwoods, and Southern pine. This expanded the pulp source and created far better timberland utilization and better markets for the woodland farmers. New forest management techniques expanded forest yields, particularly in the South, by as much as sevenfold. Finally, technology made tremendous increases in the speed and the efficiency of paper and board machines designed to run the dependable quality of virgin fiber.

Society has paid a price for this paper explosion in overflowing garbage dumps, but society has been a beneficiary, too. Paper has played a key role in the packaging-distribution-self-service revolution which has, in just one generation, dropped the relative price of food by one-third to 17% of disposal income, quadrupled the number of items available to the shopper's choice in a supermarket, and cut by half the time spent by homemakers in food preparation.

Improved paper packaging has also played an important function in reducing urban wastes. For example, some 238 million pounds of orange juice is shipped into New York City annually. But, because it is packaged, nearly 60% of the orange in the form of peels and pulp is left behind in rural Florida to be recycled into animal feed. Frozen food packaging keeps the 50% of fresh foods--bones, innards, and stalks--which become wastes out of our cities. Excello claims that if all milk now packaged in paper containers would go back to returnable glass bottles, our total wastes would increase by

30 million tons, including broken and discarded bottles, bottle caps, detergents, gasoline, water, and heating fuel.

In the meantime, wastepaper usage has received a minimum of technological help. As much as 90% of the cost of wastepaper is involved in the collecting, sorting, and transporting of the material. Highly labor intensive, collection costs spiraled with wage increase and little relief from mechanization. Traditional wastepaper products began to lose markets to virgin materials and to plastics. Technology is, finally, offering some help to recycled materials. A new type of paper machine--ultraformers--give better-quality recycled products at much higher speeds.

Recycled fibers are, at present, used for a relatively narrow line of products, and they are collected from an equally narrow line of products. An improvement in the economics of collection and recycling, a change in political and public attitudes on recycled products, and the development of new products or markets are essential to expanded use.

The public concept for making all paper from recycled paper remains unrealistic. First, about 12% of paper production is unrecoverable. It is in permanent use in building material or in books, or it is lost in residential fireplaces or in sewage systems (tissue). Second, paper is not like metal. In recycling, it cannot be made "as good as new." Each time paper is recycled, the fibers become a little shorter and a little more frayed, and the resulting paper product gets a little weaker. In some products, where strength is not a factor, recycled fiber can be used as a substitute. In other products, some carton boards for example, the weaker fiber must be compensated for by additional bulk or caliper. This could actually increase the waste from some products.

There are other limitations. Our company is a large manufacturer of food packaging. We guarantee to our customers that paper products which will come in direct contact with food will contain no materials or substances which are not approved by the Food and Drug Administration. We do not believe we can fulfill this pledge when using paper fiber collected from unknown sources or paper that has been contaminated with printing ink or other unapproved FDA substances. This applies particularly to cartons for milk, ice cream, baked goods, etc. It does not apply to carrier cartons in which the food is protected by a pouch or innerwrap.

Cartons made from virgin fiber can be produced in very low calipers while maintaining the performance characteristics required by high-speed packaging machines. For example, the familiar TV dinner cartons are now made from low-density, virgin paper board 13/1000's of an inch thick. The minimum caliper for recycled fiber board may be 16/1000's of an inch, and the increase in the weight of the carton would be more than 30%.

Combination (recycled) paperboards can do many jobs well. But, the economics, which determine board grades consider performance as well as original cost.

Corrugated shipping cartons are good users of recycled fiber now--25%--and they have prospects for expanded growth. However, new fiber must be added to the recycled material to retain the strength. At the moment, it does not look like they could exceed 40% reuse, and even that would put a difficult economic burden on the industry.

Perhaps the most difficult complexity in a mandated increase of recycled fiber is the social-economic problem. Let me illustrate it this way:

My company, American Can, has a large paper mill on the Tombigbee River in rural Choctaw County, Alabama. We are the largest employer in the county. We are the largest buyer of agricultural product in the county (trees). All of the wastepaper produced in the county would run that mill for about three hours a year. If recycled paper is to be a mandated requirement for tomorrow's paper products, this mill is in the wrong place. Question: In a nation which already has 80% of its population concentrated on 2% of its land, should we advocate a national policy which tends to drive the paper mills off the Tombigbee rivers and onto the Hackensack, the Chicago, and the Detroit? Are not sociological considerations important, too?

Actually, you could build today a wastepaper mill for substantially less money than you build a forest pulp and paper mill. On the other hand, almost all the mills built in the last 20 years were virgin fiber mills. They exist. They are not suited by location or equipment for running wastepaper. They represent a tremendous investment. They are economic only if running near capacity. They are not portable. Two thirds of all pulpwood is purchased outside the paper industry, and these pulpwood producers have a substantial investment, too.

The paper industry is making a substantial capital commitment over the next five years to better control equipment for water and air pollution. The additional demand for the special stock handling and cleaning equipment required for wastepaper use and the addition of new pollution-control equipment for the special problems of recycled paper would bring economic chaos to the paper industry if handled on a crash basis. On the other hand, a gradual move to increased recycling, stimulated economically, could be handled by normal growth falling to new mills designed for the new policy.

Incidentally, I mentioned the "special pollution problems" of recycling. Since many people suspect there would be no pollution potential with recycling, it might be well to give the problem brief mention. Recycling often required the removal of the ink which represents a disposal problem. The average deinking plant loses about 25% of its input to waste. Second, the paper itself decreases by about 10% with each recycling. The lost material escapes as suspended solid in the waste water and must be controlled. Recycled mills produce substantially more suspended solids than virgin fiber mills. Coated magazine stock, such as is used for LIFE and LOOK, will give off as much as 50 pounds of sludge (ink and clay) for each 50 pounds of fiber recovered. That is why the wastepaper dealers always sort out the magazines from the newspaper bundles after they have been collected from well-meaning citizens.

So much for the production of wastepaper products. Let us examine the collection of these materials. Remember, collection cost represents more than 90% of all costs for wastepaper. The mill wants paper that is clean and homogeneous. The collector wants maximum quantities at each stop for efficiency. These two requirements have limited most wastepaper to four collection sources:

1. Scrap from carton plants, paper converters, and printers.
2. Used corrugated boxes collected from industrial plants and retail stores.
3. Newspapers from the publishers and from public drives.
4. Writing paper waste from office buildings.

As the market for wastepaper expands, the demand on these four sources will expand first. Although almost all other paper products can be recycled, it is impractical to collect them, clean and in quantity by type, with present technology. The Black Clawson concept and some long-range work done by the Forest Products Laboratory in

Madison, Wisconsin, can change this situation. In the meantime, the potential for increased collection from the four basic sources can support the anticipated and desired growth in this market.

The economics of collection remain difficult. They can be illustrated by some studies conducted by Garden State Paper Company, the nation's largest manufacturer of recycled newsprint. They think their type of product will never penetrate more than 10% to 15% of the newsprint market. First, an efficient mill size is 350 tons a day. They do not expect to get more than 15% to 25% of the papers back from a city, and with annual per capita consumption of newsprint at just under 100 pounds, there are relatively few locations in the U. S. that could support a mill with collections. Significantly, Garden State's three mills are located near New York, Chicago, and Los Angeles, our three largest cities. Now, one point of promise on this is the experiment being run in Madison, Wisconsin. There, through the cooperation of the city government and the citizens, 40% of the newspapers are being collected.

It is a noble experiment. Still, it would take a courageous businessman to build a $65 million recycling mill on the hope that that rate of return could be maintained or duplicated in other cities.

One of the stimuli to wastepaper use always under consideration is a municipal subsidy. Most cities pay more than $30 a ton to collect and dispose of their waste. If the city would subsidize paper scavengers $15 a ton to remove paper before the city collected it, the economics would favor the growth of recycling and reduce the cost of the city's sanitation department.

There seems to be two problems here. First, most cities already charge commercial establishments for pickup and disposal so they would be saving no money. Second, and more difficult, political leaders are reluctant to commit themselves to a contract which could appear to be aiding business at the expense of the taxpayer. The public expects industry to pay for wastepaper, not get paid for taking it away. This attitude must change. A recognition of the present negative value of the waste is essential to support the economic incentives for recycling mostly all products.

Now, with that rather lengthy preamble, we are prepared to discuss designing paper containers for recycling and reuse. We have said there is little potential for recycling heterogeneous contaminated materials collected in small quantities. That eliminates most household packaging. Let me come back to that in a minute.

Corrugated containers do have some potential. Recyclers tell me they would like to get rid of asphalt tape, wax linings, hot melts, and pressure-sensitive materials. If the cases were marked conspicuously when these contaminants were used, the offending cartons could be sorted out visually. The result would be better quality in the recycled corrugated, but it would also mean higher collection costs. First, there would be more sorting. Second, the mills would refuse the contaminated material so the scavengers would need to find a second outlet. However, it is an idea that should be explored further.

Another possibility is to restrict the use of contaminants on corrugated by law or penalty. This is a more complex problem. The recycling contaminants add utility and versatility to the carton's original function. If you deny them this flexibility, you decrease their ability to compete with their competitors including wire bound boxes, steel strapped containers, plastic shippers, etc. Would this serve the objectives of better solid waste management? Certainly, such a move would require careful study.

Designing the rest of the containers in the waste for recycling or reuse still has some promising potential. We are facing a massive change in our waste handling systems. Concepts like Black Clawson call for the recovery of all fiber. If the quality problems can be worked out, this has potential for recycling or for a second use. The fiber might be combined with water soluble plastics to be compressed into building blocks. This might work some places, but not everywhere. The market for building blocks is just not that strong.

Some work has been done in converting the wood sugar in paper fibers to a high protein animal feed. It works in theory, but here, too, a severe problem of contamination must be faced.

In the concept of redesigning for either disposability or reuse, I want to caution against sacrificing the original function of the package. Paper containers are involved in extremely competitive markets. If mandated recycled fibers decrease the quality or performance or increase the price of the paper container and the market is lost to plastic or some other material, the objectives of solid waste management and resource utilization will not have been served.

Although overpackaging does exist, it reaches nowhere near the proportions credited by public opinion. Is an inner stack wrap for crackers which prevents staling of the last portions overpackaging? How about a foil-laminated overwrap which prevents dry milk from absorbing moisture or a blister card which allows small items to go self-service without excessive pilferage? Is this overpackaging? I think not, but much of the public perceives that it is.

In spite of the growth of packaging, there is a natural "brake," too. Few packages are purchased by consumers; they are bought by professional buyers. To keep their costs at a minimum, they are constantly pushing their suppliers to reduce caliper, density, and square inches. It goes on all the time, and it is successful. In the last 20 years, the familiar square half-gallon ice cream carton has improved in product protection, convenience, graphics, and machinability. But, it now weighs 33% less, and in spite of inflation, its price is lower, too.

Plastic-coated and foil-laminated containers may be more difficult to recycle. However, they allow paper to replace glass, plastic, or metal containers which may represent greater solid waste challenges.

There is one more second use with great potential for the paper in our wastes. I am thinking of energy, of course. The incinerators of the future will be expected to be producers of power as well as disposers of waste. Paper is an ideal energy source. It has a caloric value half that of coal and one-third as great as fuel oil. Unlike those fuels, however, paper is a replaceable resource. It is a non-polluting fuel. Under controlled incineration, its only by-products are carbon dioxide and water vapor, both natural to air. The plastic and wax coatings which now retard the degradability of paper would enhance its value as a fuel.

I am pleased to note that the Solid Waste Office of the EPA has placed a major contract to determine the relative value of resource recovery in the form of energy instead of in physical products. This report is a necessary prerequisite to decisions under consideration for paper recycling and container design. Without that information, such programs as the recently announced GSA purchasing specifications are premature.

Paper recycling must grow, and collection incentives offer the most promise. Gradual development of supply and market will be more effective than crash programs. Do not forget alternate use and disposal. They will remain important to handling our paper wastes.

We do need a national program and a national direction for solid waste handling. The EPA is researching this long-term course now. The existing thrust of supply and demand laws will tend to favor increased use of recycled fiber in the years ahead. In the meantime, mandated programs by public or government may be forcing industry into the wrong course of action. The solid waste problem has been building for 2,000 years. We have the facility and the organization at the EPA to develop proper solutions in the near future. I am hopeful that environmental emotion will not force us into intuitive programs when factual ones are so near at hand.

Thank you.

CONFERENCE BANQUET

Keynote Address by R. L. Lesher
National Center for Resource Recovery, Inc.

INCENTIVES FOR REUSE AND DISPOSABILITY

R. L. Lesher
National Center for Resource Recovery, Inc.

Good evening. I am delighted to be here at this important conference. Sometimes I think I must be one of the most fortunate men in the world. In this age of apology when we sometimes cringe before the problems created by the very magnificence of our achievements, when the white light of corroding criticism almost blinds us to our opportunities, I've had the chance to work on the side of the future, time and again.

I was on the team that tapped our enormous resources of imagination, technology and guts to meet the greatest challenge mankind has ever tackled. It took some years, and it took the whole-hearted effort of government and industry along with public support, but we landed Americans on the moon and brought them safely home.

And now I'm on the team represented here today -- the team that will tap those same resources to solve a problem that directly effects all of us.

The challenge of pollution has been called the moral equivalent of war. Certainly, if we fail, our fate -- though slow in coming -- will be worse degradation than victor ever imposed on loser in any war in history. And the ultimate fruits of victory are a prize more dazzling than any that can be won by arms.

The problem of solid waste disposal has been with us for a long, long time. The trash heaps of prehistoric man mutely testify that even in those uncomplicated times, it was daily concern.

The problem grew, along with the slow growth of civilization. Then about the middle of the last century, the industrial revolution quickened the pace. Slow growth gave way to quantum leaps, and ever since then, people, products and problems have multiplied explosively. I won't recite the shopworn statistics on the magnitude of the problem, but I would like to emphasize that the problem is largely a function of : (1) population growth, (2) affluence, and (3) archaic municipal solid waste collection and disposal practices.

While our economic system changed radically from an agricultural system to a highly efficient industrialized society with an ever increasing level of productivity, that is -- increasingly capital intensive and decreasingly labor intensive, our municipal solid waste practices, for the most part, changed very little and still bear a striking resemblance to the practices in vogue hundreds of years ago.

We have all been far too happily occupied with using the products industry provides -- to pay more than sporadic attention to the problem of disposal. But now, when it's becoming obvious that these problems threaten to get out of hand, people are getting frightened.

As usually happens when the alarm goes off, the immediate peril has been exaggerated. There's not denying that a tidal wave of trash hangs over us, and it's a healthy sign that people are taking note of it. The panic button has served that purpose; now it's time for a good, clear look at the problem. Fright doesn't make for clear vision, and people -- being human-- are saying and doing some foolish things. However, our clear look shows that the same industrial revolution that helped to balloon the problem to these proportions provides the technology for managing it. The affluence that contributes greatly to the problem will enable us, as a Nation, to solve the problem. This is <u>one</u> of the world's crises that can be solved. We can harness that tidal wave, and make it work for us.

The most heartening thing I discovered when I joined this effort was the quality -- and quantity -- of both manpower and mindpower already engaged.

Technology is the key to the solution and technology is pre-eminently the creation and the tool of industry. Industry does in fact deserve a share of blame for pollution, but it is ready to take the lead in controlling it. It is also able. With the example of the moon landing before us, I would hesitate to say what U.S. industry is NOT able to do when resources are available. NASA conducted the moon program, and NASA is a government agency, but everyone at NASA realized that twenty thousand industrial contractors built the invisible bridge across space that took them there.

The National Center for Solid Waste Disposal, Inc. is a non-profit corporation recently established by 13 industries and American labor. The Center is a different and unique kind of response to the solid waste challenge.

The Center's 30 member Board reads like a Who's Who is American industry and labor.

There are three points I would like to make with regard to our Board. First, the board members represent their industry rather than just their own company. In the case of labor, Mr. Abel and Mr. Minton represent all of American labor joining together to help solve the solid waste problem.

Second, this problem has the attention of <u>Top Management.</u> These board members -- although very busy -- all come to our meetings and actively support, finanacially and organizationally, the efforts of the National Center.

Third, the industries represented in the National Center at the present time are representative of those here today -- they are for the most part either producers or users of packaging.

The Center's purpose is to "put it all together" to coordinate the work of industry and labor to work with government agencies at all levels within a total systems approach.

What spurred the organizers was the need for a permanent center, national in scope, where all of industry who work with problems of solid waste can pool their experience, expertise, research money and research findings -- and where each can draw from the pool what he needs.

The basic objective of the National Center is to mobilize industrial effort on a nationwide scale to achieve lasting solutions to the problems of municipal solid waste disposal, litter control, and conservation of natural resources.

The program of the National Center will have four main elements -- 1.) Research, and, at the outset, our emphasis will be on the economics of new systems. The technology is rapidly emerging. The main gaps, at the moment, are economic gaps, markets for by-products. 2.) Analysis, which will be largely demographic analysis, data gathering of the nature of the problem, 3) hardware demonstrations and applications, and 4) a public awareness program. This will not be a public relations program of window dressing. It will be an active, imaginative, and factual education program about the nature of the problem and the nature of the solution.

Now lest you think I have strayed too far from the assigned topic -- let me come back to it. The topic of "incentives for Reuse and Disposability" -- That certainly raises some questions, doesn't it? Almost a contradiction of terms. But let's put this in perspective.

Today, we heard cited the Midwest Research Institute Study on "The Role of Packaging in Solid Waste Management 1966 to 1976." That study started all this, but everyone is overlooking some key recommendations of that report. Let me quote for you a couple of important paragraphs from that study:

"Least fruitful, in our view, would be effort expended on changing the characteristics of packaging materials. The primary reason for this is that exactly those characteristics which make it a package difficult to handle in disposal are those which make it desirable as a package. This is a way of saying that any container which is easily disposed of is a poor container; and while such a generalization could not be applied to all packages, it is applicable to those packaging categories which create difficulty in disposal.

"Most of the difficulties created by packaging are due to inadequate technology or the absence of technology in waste disposal.

"Materials research does not offer foreseeable near-term success. Research to improve the technology of salvage, particularly development of materials separation techniques, is cited as the most promising activity of those discussed."

Basically -- designing any product to be good garbage strikes me as a highly questionable approach.

Reuse of beverage and food containers dwindled a long time ago. There are a number of reasons for this. First, convenience. The second one which is implied is economy. But the third one, which everyone ignores, is environmental. The two-way containers have dropped out of sight, especially in the food case, because of the health and hygenics problems associated with taking them back through a non-systems approach.

Well, let's look at our terms. Let's understand the problem before we can solve it. What do we mean by disposability? There is nothing in our system today that can't be disposed of with the existing practices in solid wastes from coast to coast.

All of us have heard the statistics that about 85% of our cities and towns are burning or open dumping the waste of our society. So what do you mean you con't get rid of it? You can. What you are really asking is: how can you make those products more compatible with solid waste management systems which aren't in place yet? We'll have to come back to that question.

As we meet here we can make some very important predictions of the future. Virtually all of the states of the Union have laws in the books against open dumping and open burning. Dick Vaughn's leadership at the Solid Waste Management Office with Project 5000 is going to succeed in embarrassing those cities and towns into obeying those laws and closing the dumps.

Now think for a moment what that does to the state-of-the art of solid wastes management. It forces them up both the technology curve and the cost curve. And where do they go from there? The first obvious answer is the sanitary landfill. Like all of the subjects on this venue, you have pros and cons about each of these technologies. I was told that the City of Los Angeles does a pretty good job in sanitary landfills, so I went out to see what they do differently to get their cost down and not have an environmental problem. The city is running the landfill system at about $1.00 a ton and because so much land is available, they tell me that they will be doing it for the next 500 years. They have no problem with any product that is in the solid waste stream. But Los Angeles' good fortune is unique. Theirs is not the answer for the whole country, obviously.

Let us look at the advanced systems that are here today - not tomorrow. They are not in place and they are not in use - but they are here today. We have much better technology than the caveman technology that we're using. The Solid Waste Management Office has done an excellent job of doing research in a broad-faced manner in all areas of collection and disposal. You looked at the film today and say some of the more promising of those technologies. The fiber-recovery system that will be going on-line here in Ohio at Franklin next month is one technique that does, in fact, work. The CPU-400 is another bright and promising system. This is a Combustion Power Unit with front-end separation and energy conversion on the backend of the system. Garbage is burned to power gas turbines to produce electricity.

There are all sorts of experiments going on in pyrolysis, some of which produce oil and gases that can be economically consumed, thus reducing the costs. The incinerator will be with us for a long time in certain municipal situations, generating steam or other energy as a by-product.

All of these systems, incidentally, will have one thing in common: - on the front end of that system, size reduction and resource recovery and recycling of your minerals - thus helping to solve many of the problems of resource conservation. There will be grinding and air classification or other such systems. These are technologies that are here today, and while they are not perfect, they will get better.

For a moment, let's turn from talk of exploitation from waste to exploration of space --- and what I believe is a fitting analogy. In the early 1960's there must have been a thousand proposals for exploring the heavens and the planets. But, when President Kennedy set the goal of sending men to the moon within the decade, that set the pace for the technology. NASA at that time had a very vigorous, advanced research and development program, which is still being carried on today. But when the Apollo Mission was set, we had to take the state-of-the-art and fly it with that technology.

Today, the technology is here to solve the solid waste problem. The missing gaps are largely economic. One is the creation and sustaining of the markets of the byproducts of that technology and, the second gap is the financing of the system. The National Center will be working very vigorously in both of those areas. In a very short period of time, over the next several years, the whole new industry will spring out, populated by many companies that are already in or close to this industry to solve this problem and to eventually, and I emphasize 'eventually', to make money doing it.

We at the National Center have just begun. We put together our top management team and in the very near future we will begin providing services.

One thing I am sure of is that tomorrow's systems will be radically different that the practices that we have today, and it would be a shame to disrupt things that don't need disrupting and cause needless changeover and then come back to that system later on. I am confident that when we do these things, we will have a way to control any volume of solid waste that is generated in this country. I am very optimistic that we as a Nation will solve this problems, and I am damned tired of the doomsayers that seem to spring up all around us.

Today, we have the carrot and the stick. The stick is made up of those extrapolations that show us what we must expect if we do fail. The stick has us all concerned: the government, public and industry, and that concern is our guarantee that we will solve the problem.

The carrot is the wealth to be reclaimed from that tidal wave of trash. Solid waste is what we call it. The clearest threat to our environment is the label pinned on the 250 million tons of municipal waste by some other spokesman. But there is one man working on a recycling plant for the Bureau of Mines who has a different view of solid waste. He is Max Spendlove and Max calls it "urban ore." And he is right. Our tidal wave of trash can just as truthfully be called our world's richest mine, one that possesses the fairytale capability for replenishing itself. Everything useful, everything solid that was ever used eventually comes back to that mine.

The Center's ultimate goal, and I think the goal of all of us, is to realize man's age-old dream: the dream of a self-renewing horn-of-plenty, a natural resource that can never be used up. Thank you very much.

SESSION III

GLASS CONTAINERS

Chairman:

C. A. Clemons, Chief
Reclamation Branch
Division of Research and Development
Office of Solid Waste Management
U. S. Environmental Protection Agency

DESIGN TRENDS IN GLASS CONTAINERS

Richard L. Cheney
Glass Container Manufacturers Institute, Inc.

INTRODUCTION

A new dimension has been added to the marketing of such household products as: foods, beverages, drugs, cosmetics and household cleaners and chemicals. It has to do with the impact on our environment of the making, distributing and discarding of the materials marketed, including their packages.

It is within this context that I assume you wish me to discuss "Design Trends in Glass Containers."

I think we will all agree that the primary purpose of a package is to protect and preserve the contents; to hold the original freshness, goodness and strength within and to prevent contamination from without. Thus we encounter a basic contradiction in the aims of the packager and of those charged with managing solid waste. The packager wants a virtually indestructible, impermeable material and the solid waste manager would like something that would disappear into thin air as soon as its job is done. However, these aims are not irreconcilable, at least as far as glass containers are concerned, as those who follow me on this morning's program and I, myself, shall hope to demonstrate.

ENVIRONMENTAL CONSIDERATIONS

What we are concerned with here is the impact of our actions upon our environment. Max Ways, in the February 1970 issue of Fortune Magazine, puts it well in an article entitled, "How to Think About the Environment." He says:

> "Although environmental issues do have a grave moral content, there's little sense in the tendency to present the case in the dominant art form of a TV horse opera. This isn't really a confrontation between 'the polluters' and the good guys in the white hats."

and further on he states:

> "The wastes that besmirch the land are produced in the course of fulfilling

"widespread human wants that are in the main reasonable and defensible."

Surely modern packaging has done a superb job of supplying legitimate human needs and wants.

I, for one, am convinced that the same technology that has brought us the highest standard of living ever known,- if coupled with a strong sense of individual responsibility,- can solve our highly complex environmental pollution problems.

They are highly complex and are not susceptible to simplistic solutions, and time and energy devoted to pursuing impractical, simplistic solutions such as the suggestion to ban certain useful packages, is worse than wasted, for it postpones the practical solutions which must eventually be embraced.

Our environment, like charity, begins at home. The most intimate part of our environment is, of course, the home and, here, modern packaging has done much to improve our environment.

Packaging has provided "built-in maid service," thus liberating women from many household chores and permitting over half of our country's housewives to hold jobs outside the home by making possible prepared foods of all kinds, applicator packages, packages which reseal to preserve freshness, and disposable beverage containers which need not be taken back to the store.

And packages have eliminated from household garbage pails a substantial quantity of putrescible agricultural solid wastes, ranging from orange peels and pulp, vegetable and meat trimmings, and spoiled remains of unused fruits and vegetables,- by making possible pre-processed packaged foods, such as, bottled orange juice and prepared and pre-cooked foods of all kinds.

And, in addition, packaging is, of course, the automation factor in the distribution of household products.

With rising labor costs, particularly at the retail level, packaging changes and technology have streamlined the distribution process.

Packaging thus permits streamlined, sanitary, low-cost retail outlets, such as supermarkets, which can operate on a narrow profit margin and give the consumer more for his money.

At no time in history and in no other country in the world does the average citizen spend so small a portion of his total income for food as he does in this country today.

Few realize that the average supermarket operates on less than one percent profit on dollar sales. This means that when a homemaker gives the check-out boy a tip of 25¢ to take her $20.00 purchase of groceries to her parked car, the boy is making more on the transaction than the owner of the store and to a large extent modern packaging makes this progress possible.

GLASS AS A PACKAGING MATERIAL

Now, specifically, as to "Design Trends in Glass Containers," both as to their efficiency as packages and their role in solid waste management -- first, let's look at the properties of glass which affect its use as a packaging material from these two viewpoints.

Glass has several unique and impressive qualities which have resulted in its extensive use as a packaging material. In the first place, glass is made of highly abundant raw materials -- silica sand, limestone and soda ash. Sand accounts for 73 per cent of the materials in container glass. Thus, glass manufacturing is not a serious drain on our natural resources. If properly crushed in disposal processes, the glass fragments return to the soil in virtually their original state. And being inert, they do not leach, rust, rot, mold, putrefy, cause disease or noxious gases, nor pollute in any way.

Several recent studies reported in the proceedings of the American Society of Civil Engineers reveal that glass constitutes an average of only about 6 per cent by weight of residential solid waste, and an almost negligible per cent by volume, if the glass is crushed in efficient land-fill, incineration and composting operations.

Even to the scientist, glass is still somewhat of a mystery. Although regarded as a solid, physicists say it is actually a super-cooled liquid, which is why it can so easily be blown into bottles. It is transparent, although made of opaque raw materials and, in its pristine state, it is one of the strongest materials known to man. Glass fibres have been drawn which have a tensile strength of over 300,000 lbs. per square inch,- much stronger than the strongest steel.

As a packaging material, it is chemically inert, so that it cannot react with, nor add anything to, or take anything away from its contents. It is absolutely impermeable to gases or moisture, transparent, non-porous, sanitary and odorless and may be formed in an infinite variety of shapes, sizes and colors. No other packaging material can say as much.

Incidentally, that great strength of glass is a big factor in the plans of a noted scientist who is planning to package people in glass! Dr. William B. McLean, known as "the Navy's handyman" (he invented the side-winder missile) is designing a 56 inch glass sphere (called a "bathysphere") in which two men will descend deeper in the ocean than man has ever gone before.

Dr. McLean points out that not only is glass transparent, so that they will be able to see in all directions, but (and I quote him), "It is not theoretically possible to make a metal vehicle that can stand the ocean's pressure without being far too heavy. The big advantage of glass, beyond visibility, is that glass is lighter than any metal and about 5 or 6 times as strong as steel."

Now Dr. McLean's container will operate under heavy external pressure, which puts the whole glass structure under compressive stress. Ordinary glass containers are subjected in normal handling and, as a result of internal pressure from carbonic gas (such as in soft drinks) or propellants (such as in aerosols), to forces which result in tensile stress, and if a bottle fails, it does so when its tensile strength at some point is exceeded.

Today in glass bottles we are utilizing only about one percent of the theoretical tensile strength of glass exhibited by the glass fibre. When we learn to lift this only to five percent, we shall be able to make glass bottles and jars much lighter (that is, with much less glass in them) than today, and much stronger. This will not only make it a more desirable package to the consumer and save on shipping weight, but it will obviously reduce the weight of waste glass in the solid waste stream when it is discarded, substantially reduce the amount of protection required in the corrugated shipping container,- thereby reducing that load on solid waste.

You will hear later this morning of new developments in lighter glass containers and research is well along on a process of chemical tempering which will put the surfaces of the containers under compressive stress and so result in the lighter containers I have described. We hope to see a breakthrough in this area soon. One of the beauties of this development will be that such containers when broken in disposal will fall into harmless granules about the size of rock salt.

Meanwhile, research and development has already brought about a reduction in weight of some 30 percent in glass containers over the past 20 years. One factor in this progress has been a marked advance in the techniques for surface treatments which have resulted in substantial progress in protecting and preserving the pristine strength of the surfaces of beer and soft drink bottles which have to withstand the internal pressures of carbonation. Much of this research has been conducted jointly through GCMI.

The other outstanding characteristic of glass, its chemical inertness, which guarantees complete compatibility with its contents and virtually unlimited shelf life unless the contents breaks down of itself, was recently dramatically demonstrated by an incident reported in the New York Times.

In 1968 an English lord discovered in his wine cellar three glass bottles of Canary Island wine, bottled in 1740. He and his son sampled this 227 year-old wine and found it to be delicious. They put one bottle away for a future family occasion and a London autioneer sold the third for them at a fancy price. That is real shelf life and, of course, could be equalled by no other modern packaging material!

This brought to mind another incident when, in 1954, 18 bottles of beer were washed ashore on the Kentish coast of England, after spending 250 years under the sea in a wrecked ship. They were intact, with their contents, and neither the corrosive sea water nor its crushing pressure had violated their integrity as a package. The beer was potable, but had definitely not improved with age.

One further example of the efficiency of glass as a package was cited in the April 9, 1971 issue of Research Institute of America's bulletin. A graduate student at University of Maryland has found that nitroglycerine tablets, used by heart disease sufferers, may lose up to 30% of their potency within six months in one type of package made of a material other than glass, up to 72% in another, and up to 90% in a third; while they lost only 5% of their potency in glass bottles over that period, either with glass stoppers or tight screw-on caps.

I cite these examples to show that glass as a packaging material has such important advantages to the consumer that it would, for example, be a very serious mistake to recommend substituting some biodegradable material for it in the hope (which is open to question) of decreasing our solid waste problems. You will, however, hear later in the morning of research directed toward the possible use of a different type of glass itself, which has unusual disposal characteristics.

Finally, glass is one of the most easily recycled of all the materials found in solid waste and we have already uncovered markets for all of the waste glass that could be generated in this country. We are supporting research to develop systems for automatically separating it from municipal solid waste so that it can be re-used for these purposes. You will hear more of this later in the morning.

SUMMARY

In summary, as I have pointed out:

1. The use of glass containers conserves limited raw materials.
2. They benefit our home environment and are essential to our present mode and standard of living.
3. The properties of glass which make it an excellent container material also make it a beneficial factor in all accepted waste disposal systems.
4. Glass containers constitute only 6% of municipal solid waste by weight and, when crushed, less than half that by volume.
5. Through research and development we are moving toward lighter weight glass containers which will benefit the consumer and further reduce the solid waste load.
6. Glass containers represent one of the most easily recycled and re-used of all the elements of municipal solid waste and present reclamation programs and research are directed

6. Cont'd.

towards maximum use of waste glass as a secondary material.

RE-USING SCRAP GLASS

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INTRODUCTION

The use of waste glass as aggregate in asphaltic concrete has been under study at the University of Missouri-Rolla for nearly two years under a grant from the Solid Waste Office of the Environmental Protection Agency. Since containers constitute over 75 percent of the waste glass present in municipal refuse, the properties of waste glass would depend, to a large extent, upon the properties of containers. Thus, changes in composition and design of consumer containers might be expected to be of concern. The degree to which this potential for waste glass reuse is influenced by container design, is discussed in this paper.

PROPERTIES OF GLASS-ASPHALT MIXTURES

Aggregates which are normally used in asphaltic mixtures may vary from porous to nearly nonporous materials with rough to smooth surface textures. Angular materials such as crushed stone have been used as well as rounded gravels and river sands. Generally, particles which are nearly equidimensional are preferred to flat and/or elongated particles. A range in sizes from up to 1 1/2-in. particles graded down through sand and dust sized materials is generally used if a dense mass is desired but the maximum sized particle used will vary with the source of supply and the thickness of the pavement layer to be placed.

Waste glass particles can be characterized as nearly non-porous, smooth surfaced and angular with a preponderance of flat particles in sizes retained on a No. 4 sieve. The non-porous nature of glass is advantageous in that lower drier temperatures are required in plant mixes since only surface moisture must be expelled. However, the low porosity and smooth surface texture combined result in less internal friction in the asphaltic mixture and thus a lower strength or stability. The large number of flat particles in the larger sizes is not unexpected since an average bottle wall thickness is approximately 0.11 in. and particles with any dimension greater than 3 times this value would be classified as flat and/or elongated. While excessive numbers of flat or elongated particles are undesirable, due to lower densities and strengths obtained when using them, research currently being conducted has indicated that by changing the particle size gradation, denser mixes can be achieved with flat and elongated particles. It is necessary to have a graded mixture of glass particles in order to obtain adequate density and strength.

Asphaltic mixtures satisfying standard design criteria have been designed using penetration grade asphalts and aggregates composed entirely of glass[1]. While the stability of these mixtures is somewhat lower than stabilities obtained using crushed conventional aggregates, values greater than the minimum required stability for medium traffic categories have been obtained. In field installations using a mixture of glass and conventional aggregates, stabilities have been considerably higher than those obtained with all-glass aggregates[2]. These stabilities have met the requirements for heavy traffic categories suggested by The Asphalt Institute[3].

Resistance to loss of adhesion between asphalt and glass in the presence of water is poor if no additives are used to improve adhesion. However, the addition of hydrated lime in an amount equal to one percent by weight of the aggregate resulted in very much improved adhesion so that specimens which had been soaked in water at 140F for 24 hours retained 100 percent of the dry strength[4].

Skid resistance and tire wear on glass aggregate surfaces have not yet been fully evaluated. In Fig. 1, the surface texture of a patch containing

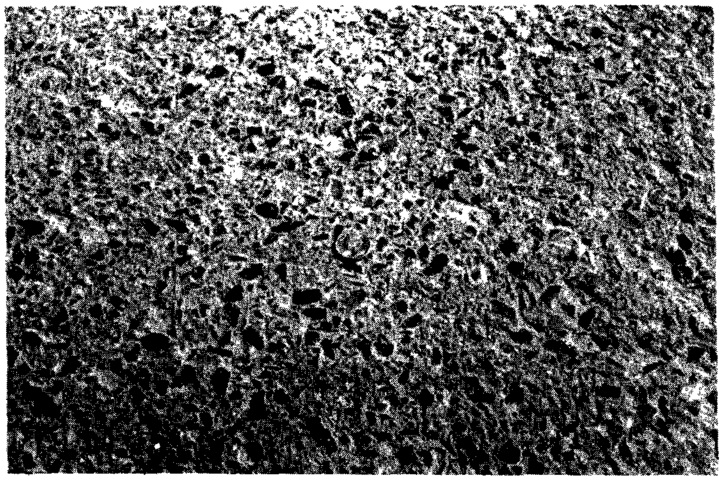

Fig. 1 Glass-asphalt surface containing 94.5% glass 4 months after placement

Fig. 2 Glass-asphalt surface containing 94.5% glass 17 months after placement

94.5 percent crushed glass and 5.5 percent asphalt is illustrated. The picture was taken 4 months after placement. It should be noted that the larger flat glass particles lie flat in the pavement surface with no jagged edges protruding. Fig. 2 shows the same surface 17 months after placement. Since hydrated lime was not used in this mixture there has been considerable ravelling of the surface, but note again that there is no indication of potential tire cutting edges appearing. A similar surface texture has been observed in field installations using glass particles up to 3/4-in. in size, and thus we feel that there is little danger of actual cutting of the tires due to exposed glass edges.

Whether or not glass aggregates contribute to an increased rate of abrasion for tires can not be answered yet. Schallamach[5] states that rate of abrasion of typical tread compounds on tracks with different surface characteristics can vary by a large factor but it is not so much size as shape of track asperities which determines severity of wear. This would seem to indicate that the more angular glass particles would result in greater wear than rounded or semi-rounded aggregates. However, research has shown that wear also occurs on smooth surfaces due to fatigue of the rubber. According to

Schallamach, tire surface temperature is the basic parameter from which practical tire wear ratings can be derived, and while the possibility must be left open that road surface affects ratings, it is still expected that tire surface temperature governs wear ratings on any given road, irrespective of its characteristics. A laboratory apparatus for assessing tire wear on varying surfaces is currently under construction since it appears that the only method for obtaining a quantitative comparison of wear on surfaces with conventional and glass aggregates is by direct testing.

Skid resistance tests have been conducted on several of the field installations of glass-asphalt mixtures using the British Portable Tester and the ASTM two wheel skid trailer. The results obtained to date indicate primarily the initial skid resistance, and the effect of traffic upon these skid resistance values has not been fully evaluated. However, initial skid values obtained have been acceptable. The results of these initial determinations are given in Table 1.

One property of glass-asphalt mixtures which has been noted by contractors placing the material in field installations is a slower cooling rate. Hot mixed asphaltic concrete is generally

TABLE 1

RESULTS OF INITIAL SKID TESTS ON GLASPHALT FIELD INSTALLATIONS

LOCATION	DATE INSTALLED	DATE TESTED	TEST METHOD	TEST SPEED	SKID NUMBER
Owens-Illinois Toledo, Ohio	10/4/69	10/16/69	ASTM E274	20 mph	63
Dominion Glass Co. Ontario, Canada	8/29/70	9/70	ASTM E274	20 mph	54
Glass Containers Corp. Fullerton, California	10/26/70	3/2/71	ASTM E274	40 mph[a]	58
University of Missouri-Rolla Rolla, Missouri	7/10/70	7/12/70	British Portable Tester	--	56

(a) Test conducted at 25 mph and converted to 40 mph.

delivered to the job site at temperatures ranging from 250F to 300F. It is then necessary to complete compaction before the asphalt viscosity increase due to cooling progresses to the point that further compaction is impossible. During cold weather excessive cooling is a problem which can result in high void contents and premature deterioration due to inadequate compaction. Since several contractors commented on the apparent slower cooling rate for glass-asphalt mixtures, several laboratory tests were conducted to compare these mixtures with conventional asphaltic concretes. Companion specimens were fabricated using conventional crushed limestone and river sand for one set and glass aggregates for the other. Properties of the mixtures are shown in Tables 2 and 3. They were compacted in standard Marshall molds in which the metal base plate had been replaced by a plywood plate of the same dimensions. A groove in the base plate contained a chromel-alumel thermocouple for measuring temperature. Each of the two specimens was compacted using 50 blows of the standard hammer on one side only. They were then placed in an oven at 120C for 24 hours to stabilize temperatures, before placing them in a cold room at 0C. The specimens remained in the compaction mold while temperature readings

TABLE 2

GRADATION OF AGGREGATES FOR COOLING STUDIES

GRADATION	GLASPHALT	CONVENTIONAL ASPHALTIC CONCRETE
SIEVE SIZE	% PASSING	
1/2"	100	100
3/8"	87	87
No. 4	61	61
No. 8	46	46
No. 16	36	36
No. 30	28	28
No. 50	17	17
No. 100	10	10
No. 200[(a)]	5.5	6.5

(a) Crushed limestone used for mineral filler in conventional mix. In glasphalt mix, 1.0% hydrated lime and 4.5% crushed glass dust was used.

TABLE 3

PROPERTIES OF ASPHALTIC MIXTURES USED IN COOLING STUDIES

PROPERTY	GLASPHALT		CONVENTIONAL ASPHALTIC CONCRETE	
	TEST 1	TEST 2	TEST 1	TEST 2
Air Voids %	3.62	4.79	3.73	3.62
Voids in Mineral Aggregate %	15.78	15.90	15.78	14.80
Compacted Unit Weight, pcf	138.9	138.8	138.7	139.6
Asphalt Content, % Total Wt.	5.5	5.5	5.5	5.5

were taken at time intervals varying from one to fifteen minutes.

Results of two such tests are shown in Figs. 3 and 4. In test one, air contents of the compacted specimens were almost identical while in test two, the glass-asphalt mixture had a higher air content. However, in both these tests, the temperature of glass-asphalt mixtures was consistently higher than the conventional mixture very soon after cooling had begun. More study is needed in order to confirm this behavior and to evaluate its practical significance, but if the higher heat retention is confirmed, extension of the paving season in colder climates would be possible.

ECONOMIC CONSIDERATIONS

In a paper concerning economic factors of mineral waste utilization, Vogely[6] divides wastes into three groups based upon their economic value and the social cost inherent in their generation and existence. The first category includes wastes which have a value, such as iron mine rejects with a substantial percentage of iron but not immediately marketable because of technological and economic problems. Vogely also includes in this category wastes which have no significance from the point of view of the materials which they contain but are

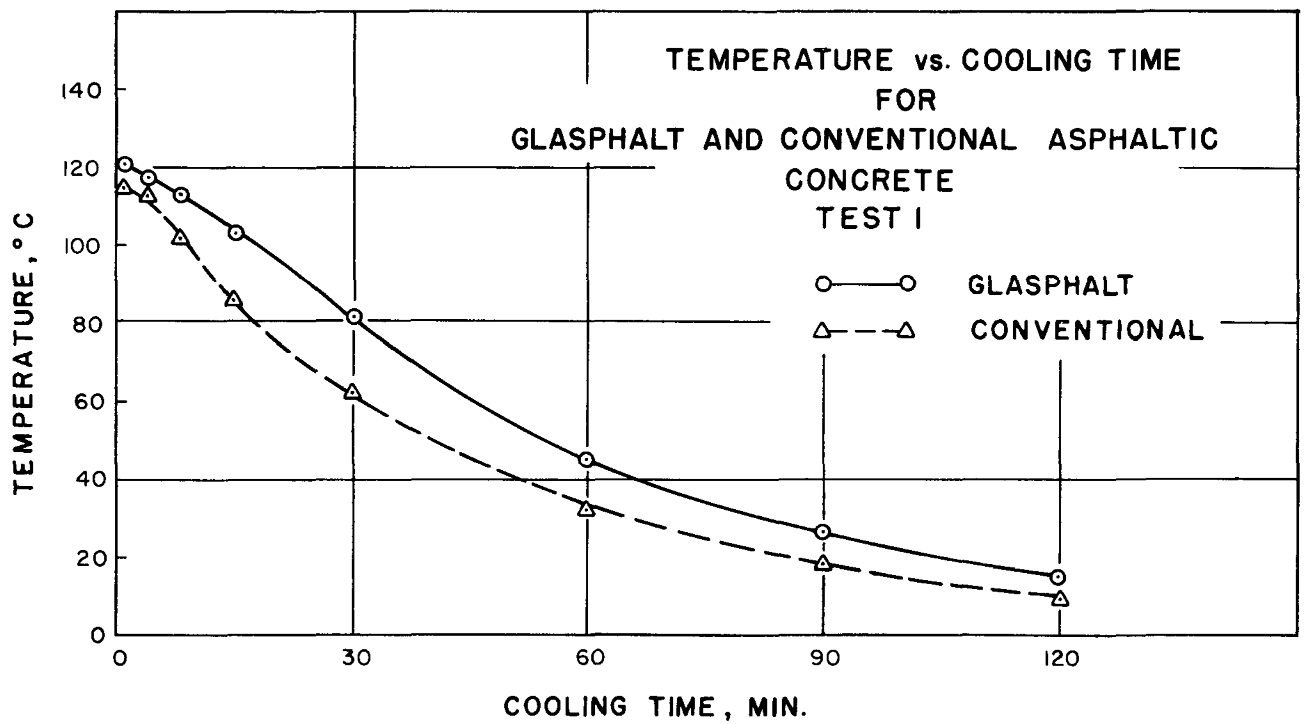

FIG. 3 COOLING RATE OF GLASPHALT AND CONVENTIONAL MIXES - TEST I

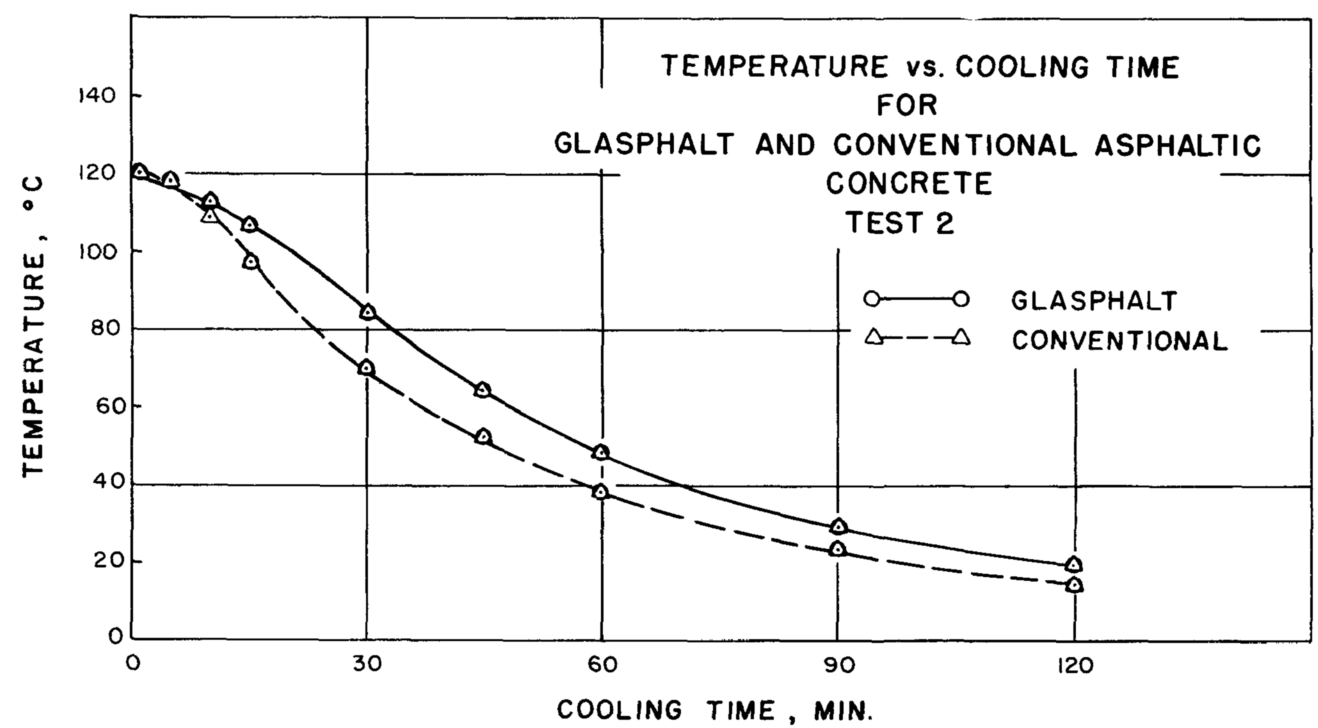

FIG. 4 COOLING RATE OF GLASPHALT AND CONVENTIONAL MIXES - TEST 2

important for their structural characteristics in that they could be used as aggregates.

The second category includes wastes which are worthless but which generate spillover costs to the rest of society in the form of health and safety hazards, retarded land development or destroyed aesthetic values. Finally, there are those wastes which are worthless but exist in such small volume and are so remote from population centers that they do not generate any social costs.

Until recently, waste glass from municipal refuse was included in the second category, being viewed only as a worthless material to be disposed of. However, in the past two years, the value of this waste component has been recognized[7] and several possible means for reusing waste glass have been suggested. The possibilities include use in making more bottles, as an aggregate for road paving, and as a raw material for glass bricks, fiberglass, or other high silica building materials. In choosing among these possible uses, a market allocation problem is evident. According to Vogely, the issue is whether or not the market place adequately measures the potential value as a source of minerals (cullet) against a current value in a use (aggregate) which destroys that value. It would appear that the choice will hinge upon several factors.

If we assume that a separation facility for municipal refuse is installed to produce metallic (both ferrous and non-ferrous), paper, plastic and glass fractions, the economic feasibility of using the glass as an aggregate will depend upon the amount of further processing necessary in order to make glass suitable for use as an aggregate, the cost of conventional aggregates in the area, and the volume the waste glass fraction produced annually. The most desirable situation would be one in which the glass emanating from a separation facility could be used as an aggregate with no further crushing, screening or washing operation. Assuming that ten percent by weight of the refuse processed was glass and that this glass could be used to replace aggregate costing $2.00 per ton, the glass component would generate an income of $.20 per ton of raw refuse processed. In the Black Clawson hydrasposal/fiberclaim system, separation costs for a 1000 ton per day unit are estimated at $7.50 per ton of raw refuse processed(8). The $.20 per ton revenue generated by the glass thus represents a small percentage of the separation cost. However, in this particular system, revenues realized through the sale of recovered fibers are expected to bear the brunt of separation costs as it is estimated that reclaimed paper worth $5.00 can be recovered from each ton of raw refuse. Credits to offset part of the remaining $2.50 would be expected from the sale of ferrous metals, aluminum and glass.

Samples of the glass fraction produced by the hydrasposal system have been analyzed to determine the particle size gradation and amount of contaminants present. Results of the sieve analysis are shown in Table 4. Based upon a visual and magnetic separation, roughly 15 percent of this fraction consisted of non-glass materials such as aluminum labels, ferrous metals, plastics and rubber. The gradation indicates the material to be too coarse for use by itself in glasphalt. However, by blending it with a sand or rock dust the gradation could be improved enough to make it usable without the further cost of crushing or screening. The effect of the 15 percent impurities is presently being studied, but no conclusions can be drawn as yet.

If crushing, screening or washing were required to make the glass fraction suitable for use as an aggregate, the glass fraction would not contribute as much toward offsetting separation costs. Due to the need for purchasing specialized equipment,

TABLE 4

GRADATION OF GLASS FRACTION FROM REFUSE SEPARATION FACILITY

SIEVE	PERCENT PASSING
1/2-in	100
3/8-in	96
No. 4	69
No. 8	26
No. 16	9
No. 30	2
No. 50	1
No. 100	0

it would be necessary to process some minimum volume of glass in order to reach a break-even point. The minimum volume necessary would be dependent upon processing costs, including equipment, and upon the cost of aggregate to be replaced by glass. From the results of a preliminary economic analysis(2) in which it was assumed that crushing and screening equipment were purchased for the processing operations and conventional aggregates cost $2.00 per ton, a break-even point of roughly 30,000 tons of glass annually can be estimated. At volume below this figure, the cost of processing the glass for use in glass-asphalt mixtures would exceed the savings as a result of reduced use of conventional aggregates. The only justification for using the material as aggregate under these conditions would be a case in which disposing of the waste glass in a landfill would be more costly than using it as an aggregate. It might also be argued, in accord with Vogely's point, that with further processing such as removal of nearly all contaminants and color separation, the glass could better be used as cullet. The choice to be made, in this case, would depend upon other factors such as the cost of cleaning and color separation, costs for transporting the cullet to the nearest bottle factory, and the amount of glass which could be disposed of in this manner.

In summary, if glass from a separation facility is used as an aggregate, and no futher processing is required, the maximum contribution toward offsetting separation costs would be made, but this amount would represent only a modest percentage of the separations costs that are currently projected. If crushing and screening of the glass are required, the contribution toward offsetting separation costs is diminished and a minimum volume must be produced annually in order to balance the additional processing costs. These estimates are based upon prevailing aggregate prices and projected costs for separating refuse in a facility which is currently under construction. The economic feasibility of this approach would be enhanced by higher aggregate prices, for instance, if it were found that the thermal properties of glass-asphalt mixtures justified a premium price for the aggregate.

IMPACT OF DESIGN CHANGES IN GLASS CONTAINERS

According to Darnay and Franklin[9] several changes in glass container design might be anticipated within the next decade. Lighter containers produced using thinner walls and stronger glass are expected since the higher weight of glass containers is considered to be one of their major disadvantages.

Glass-plastic containers of exceptionally light weight are also being developed(10). Advances in glass technology have resulted in more colors being available and decoration by fusing enamel onto the glass surface directly. More novel color-shape combinations are also expected to appear. Easy-open closures in the form of twist-off caps have already been introduced, with the twist-off caps leaving a slender ring of aluminum around the neck of the bottle.

Changes in color, shape, or decorating method will have no effect upon the potential use of waste glass as an aggregate in asphaltic mixtures. Only an alteration of the glass surface texture would influence the mechanical properties of asphaltic mixtures and, since the smooth surface texture of glasses currently being used represents the worst possible condition for high internal friction and strength in the mixture, any changes in surface texture caused by decorative technique would probably be beneficial.

Thinner walled containers will result in more flat and elongated particles being present in the larger size fractions of crushed glass. The effect of these particles would be to decrease density and strength of the glass-asphalt mixture(11).

However, there is some evidence that these effects can be mitigated through alteration of the glass gradation used. A commonly accepted means for calculating a so-called maximum density gradation for granular materials is the Fuller formula:

$$P = 100\ (d/D)^n$$

where

- P = percent passing a sieve having an opening of d inches
- D = maximum size of aggregate
- n = a coefficient related to physical properties of the aggregate

Goode and Lufsey[12] have suggested that for maximum density, n be taken as 0.45. However, it has also been suggested[13] that, depending upon the shape of aggregate particles, the coefficient producing maximum density may vary. In laboratory studies aimed at establishing an optimum gradation for crushed glass, the density of various gradations of glass beads and crushed bottle glass indicated that for the equidimensional, rounded beads the 0.45 coefficient did produce maximum density but that for crushed bottle glass, a coefficient of 0.375 was necessary for maximum density. These results are shown in Fig 5 and it should be noted that in all cases the glass beads gave higher densities. Thus, it appears that while increased flat particles do

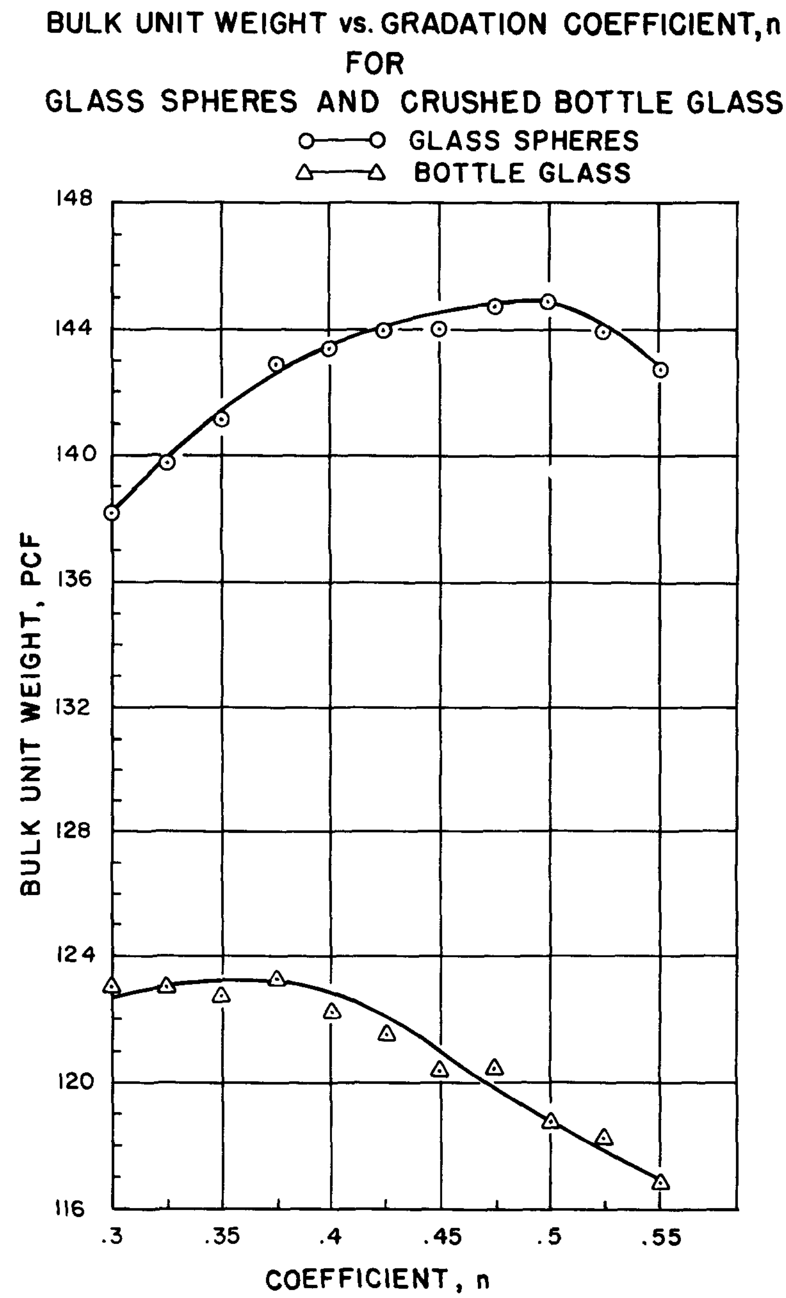

FIG. 5 UNIT WEIGHT OF GLASS SPHERES AND BOTTLE GLASS

cause a loss in density, changes in the gradation used can minimize this loss. Tests are currently being conducted on asphalt specimens utilizing the varying gradations to determine strength values using the optimum density gradation.

The effect upon glass-asphalt mixtures of contaminants such as aluminum rings, bottle caps, and plastic residues from composite containers have not yet been fully investigated. Research sponsored by the Glass Container Manufacturers Institute is currently underway at the University of Missouri-Rolla to assess the effect of several contaminants upon the properties of glass-asphalt mixtures and results to date have indicated that up to 1.5 percent aluminum by weight of the glass aggregate used has no adverse effect upon strength or void characteristics of the mixture. The effects of plastics have not yet been evaluated.

CONCLUSIONS

In summary, changes in container design which might be expected to occur over the next ten years should have little effect upon the suitability of waste glass for use as an aggregate in asphaltic concrete. The major barriers to effective utilization of the glass in this manner are economic ones which are related to the costs of separation and the costs of any further processing of the glass which is necessary after separation.

ACKNOWLEDGMENTS

This investigation is supported by Environmental Protection Agency Grant No. USPH 5 R01 EC329-02 and by a grant from the Glass Container Manufacturers Institute.

Skid resistance data on glasphalt field installations were furnished by Ohio Department of Highways, California Division of Highways and the Ontario Department of Highways.

Samples of glass recovered from the hydrasposal fiberclaim system for refuse separation were furnished by the Black-Clawson Company.

Thomas Keith and John Doyle, Research Assistants in Civil Engineering, at the University of Missouri-Rolla, aided in obtaining laboratory data concerning thermal properties and effects of flat and elongated particles in waste glass mixtures.

REFERENCES

(1) Malisch, Ward R., Day, Delbert E., and Wixson, Bobby G., "Use of Domestic Waste Glass as Aggregate in Bituminous Concrete," Highway Research Record, (307) 1-10, (1970).

(2) Malisch, Ward R., Day, D.E., and Wixson, B.G., "Use of Salvaged Waste Glass in Bituminous Paving," paper presented at special symposium on Technology for the Future to Control Industrial and Urban Wastes, Rolla, Mo., (Feb. 1971)

(3) Mix Design Methods for Asphalt Concrete, Third Edition, The Asphalt Institute, College Park, Maryland (October 1969) p. 39.

(4) Foster, Charles, W., "Use of Waste Glass as Asphaltic Concrete Aggregate," Masters Thesis, University of Missouri-Rolla, Rolla, Missouri, (1970), p. 29.

(5) Schallamach, A., "Recent Advances in Knowledge of Rubber Friction and Tire Wear," Rubber Chemistry and Technology, 41 (209), 221-241 (1968).

(6) Vogely, William A., "The Economic Factors of Mineral Waste Utilization," In Proceedings of the First Mineral Waste Utilization Symposium, Chicago, Illinois (March 1968).

(7) Abrahams, John H., "Utilization of Waste Container Glass," Waste Age, 1 (4) (July-August 1970).

(8) Marsh, Paul, Private Communication, April 1971.

(9) Darney, Arsen, and Franklin, William E., "The Role of Packaging in Solid Waste Management 1966 to 1976," Public Health Service Publication No. 1855, Washington, 1969, p. 34-35, 131.

(10) Owens-Illinois, Annual Report, 1969, p. 20.

(11) Bituminous Materials in Road Construction, First Edition, Her Majesty's Stationery Office, London, England (1962), p. 13.

(12) Goode, J.F. and Lufsey, L.A., "A New Graphical Chart for Evaluating Aggregate Gradations," Association of Asphalt Paving Technologists Proceedings, 31, 177-180, (1962).

(13) Smith, M.R. and Kidd, G.M., "Concrete Technology and Aggregate Production for St. Lawrence Seaway," American Concrete Institute Journal, 56 (11), 361-376, (November 1959).

TECHNIQUES FOR SELF-DISPOSAL

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INTRODUCTION

Improperly discarded containers such as glass bottles or metal cans are not only unpleasing litter, but also provide homes or water receptacles for common disease carriers such as rodents or mosquitoes. Furthermore, broken bottles and sharp-edged metal containers are a major hazard in streets, playgrounds, and parks. Unlike some types of metal containers, which will eventually corrode and disintegrate, glass objects and fragments will last indefinitely. With rising costs of pickup and disposal of litter and trash, it has become increasingly difficult to dispose of about 26 billion glass containers per year, which are manufactured in this country.

Since littering cannot be stopped completely, it has been suggested to construct packaging containers from degradable compositions. Biodegradable materials have not yet been developed or fully accepted. Alternatively, it has been considered to utilize water soluble container structures, which will dispose of themselves upon prolonged contact with surface water. Compositions are well known for producing water soluble glasses that would be inexpensive and sufficiently strong to contain the pressure within bottles of carbonated beverages. However, effective ways must yet be found to establish a suitable barrier between the water soluble structure material and the contents of the container. The container as a whole must eventually be economical and durable, and the barrier formulation must effectively prevent any appreciable permeation of contaminants into the contents of the container. Furthermore, the coating must also be able to withstand on a short term basis any heat treatments that are required for sterilization procedures prior to filling the containers.

DISSOLVABLE GLASSES FOR CONTAINER UTILIZATION

It is well known that glasses prepared from the silicates of alkali metals are water soluble. Among these the sodium silicate compositions are least expensive, although somewhat higher in inherent cost than ordinary soda-lime glasses. The difference in cost may be compensated for to some extent by savings in fuel costs that arise from the attainment of melt viscosities suitable for manufacturing at lower temperature with soda glass, as compared to conventional glass formulations. These insights into manufacturing problems have been gained by collaboration with investigators of the Anchor-Hocking Corporation, who have actually pressure-molded some glassware from soda glass as a demonstration project. Most of such work was performed with a glass composition of $35\%Na_2O\cdot 65\%SiO_2$, at which composition the dissolution of glassware objects in water at room temperature would require several weeks. Samples of the soda glass have under some conditions exhibited higher flexural strength (28,000 psi under four-point loading) compared to ordinary soda-lime glass (about 10,000 psi under the same test conditions). These findings can be attributed to interactions with moisture at the surface of the soda glass, and surface cracks will become blunted effectively with the more reactive glass composition.

Actual dissolution of soda glass is likely to form a slimy precipitate of silica gel, along with some sodium hydroxide. The latter product is likely to react with carbon dioxide from air or from decaying organic matter; or otherwise the base may react with widely occurring acidic components of the soil or with acidic solutions that reportedly leach out from landfill material. Dissolution of our glass composition is slow, and under agitation at 25 °C it has been determined to proceed at about 3.0×10^{-5} g/min per cm^2 of surface (see Fig. 1). A steady dissolution rate has been observed if carbon dioxide is excluded carefully from the solution. Less careful experimentation can readily come up with unsteady dissolution rates due to accumulation of some surface layers that form and flake off intermittantly. Presumably, any dissolved carbon dioxide will contribute to such layer formation.

APPLICATION OF POLYMERIC BARRIER COATINGS

The utilization of soluble glass for container structures depends significantly on our ability to develop

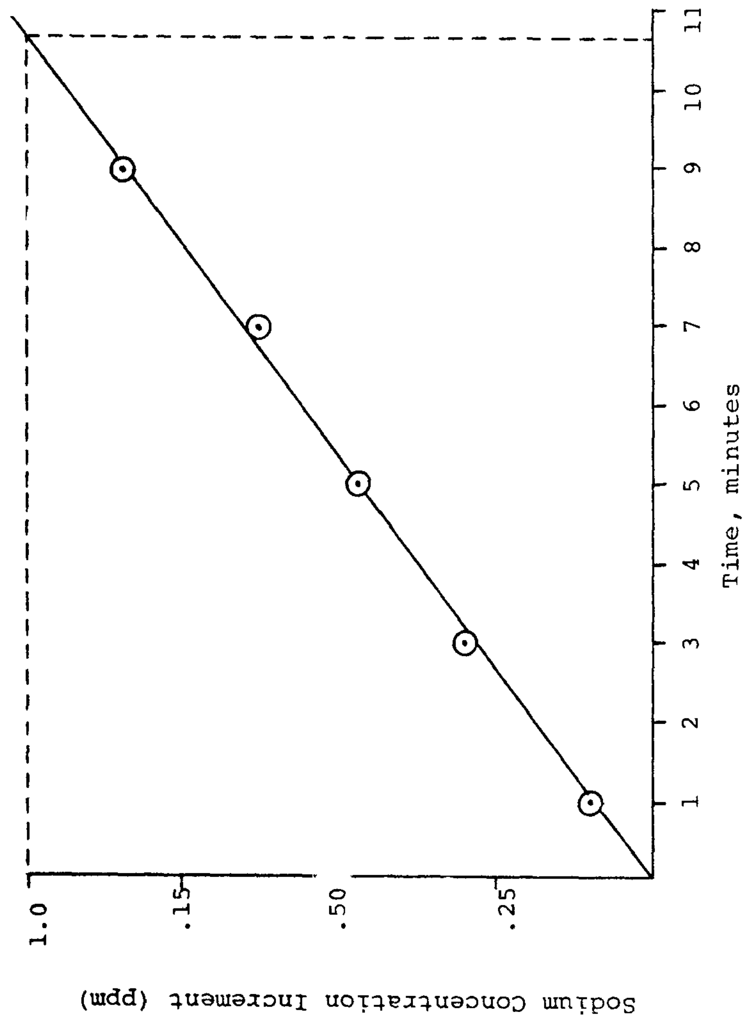


FIGURE 1. ACCUMULATION OF SODIUM IONS IN 200 CC OF AGITATED WATER AT 25^{o}C, DUE TO DISSOLUTION OF A 3MM DIAMETER ROD OF SODA GLASS, AT 1 INCH IMMERSION.

coatings that will act as barriers between the glass and the contained aqueous phase. Application of coatings will enhance container cost, but if a polymeric material is used, some shatterproofing may be attained. Someday the consumer may be required to pay for such shatterproofing anyway, but the cost of applying polymer coatings from solution is not anticipated to be excessive.

Rather special requirements must be met by the polymer coating in order that long-term contact with aqueous media and short-term heat exposure will be tolerated. During application the glass surface must be wetted by the polymer reliably, and very good adhesion must persist during all stages of actual use. Even though some moisture will be able to permeate the coating, the generated osmotic pressure must not be capable of prying the coating membrane away from the solid substrate. The tendency for this latter effect to take place has been encountered with several coatings of inadequate composition (see Fig. 2).

In efforts to attach a polymer coating firmly onto the sodium silicate surface, a priming coat of polyvinyl hydrogen phthalate has been employed. This polymer can be applied at one mil thickness by dip-coating from solution, with methyl ethyl ketone as solvent. The polymer is only sparingly soluble in water, and it does not even dissolve readily in sodium hydroxide solution. Adjacent to the soda

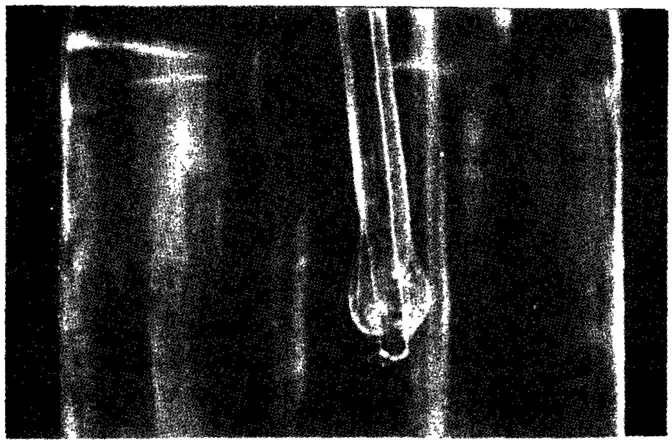


FIGURE 2. TYPICAL BALLOONING EFFECT, DUE TO LIQUID ACCUMULATION BETWEEN SODA GLASS AND A DEFORMABLE COATING.

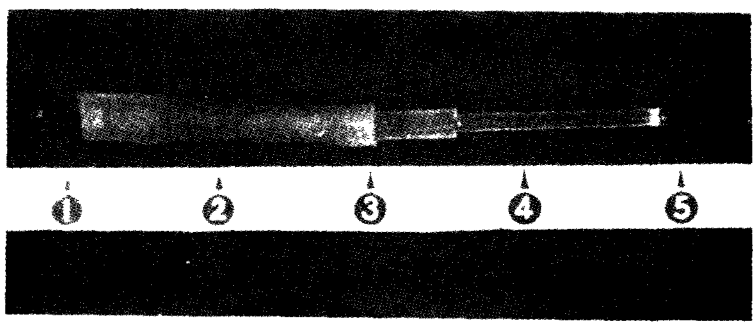


FIGURE 3. TYPICAL ASSEMBLY UTILIZING A FIREPOLISHED GLASS ROD TO CARRY A COATING SYSTEM AND A PROTECTING HANDLE.

glass structure and in the dried state, the polymer offers functional groups for establishing strong dipole-dipole interactions with the glass surface.

A second dip-coating process has so far been employed to apply a durable barrier coating of a different composition. As yet we do not know of any suitable barrier coating that will also prime the glass surface effectively. However, several different polymer compositions have been found to be suitable as the top coating. Thus Saran-type polymer can be seated firmly on top of the priming coat, or a methacrylate lacquer can be employed as the barrier film. Most experience has been gained with the latter type of polymer, i.e. with a 50-50 copolymer (approximately) of methyl methacrylate and butyl methacrylate, equipped with some free carboxyl groups. The lacquer composition was supplied in solution with a mixed solvent of toluene and isopropanol by the DuPont Company under the tradename "Elvacite 6014." Other lacquer formulations from this acrylate family of products have also been tried, but they were found to be less adequate in our testing procedures.

A great deal of testing work was done with fire-polished rod pieces of soda glass. The rods served as pieces of material to carry the subcoat and topcoat compositions and as a convenient handle as well. After application of the polymer coatings in separate dipping and drying cycles, the uncoated rod section was covered by rubber tubing (see Fig. 3) for protection against moisture during subsequent partial immersion in thermostated aqueous solutions. The immersion tests were performed in order to evaluate quantitatively the rate of sodium permeation across the coating, along a measured area of the coating composite, under steady agitation at controlled temperatures. At various time intervals, aliquot samples of test solutions were withdrawn from the reservoir of known volume, and sodium concentrations therein were eventually determined by atomic absorption determinations, using a Perkin-Elmer apparatus (Model 403). Each coated rod specimen was used in several series of experiments, which finally revealed the temperature dependence of the sodium permeation process.

The sensitive analytical equipment enabled a determination of the slow permeation rates for the hydrated sodium ions (see Fig. 4). Subsequently, the temperature dependence of the permeation rates were summarized in an Arrhenius plot (see Fig. 5). A discontinuity in this plot appears at $60 \pm 1^{o}C$, which is interpreted as the glass transition in the barrier coating. Below this temperature the glassy state prevails in the coating, and an activation energy of 35 kcal/mol has been calculated for the permeation process. Experimental data obtained with acidic (pH=2.7), neutral or basic solutions (pH=10.7) are in agreement on this

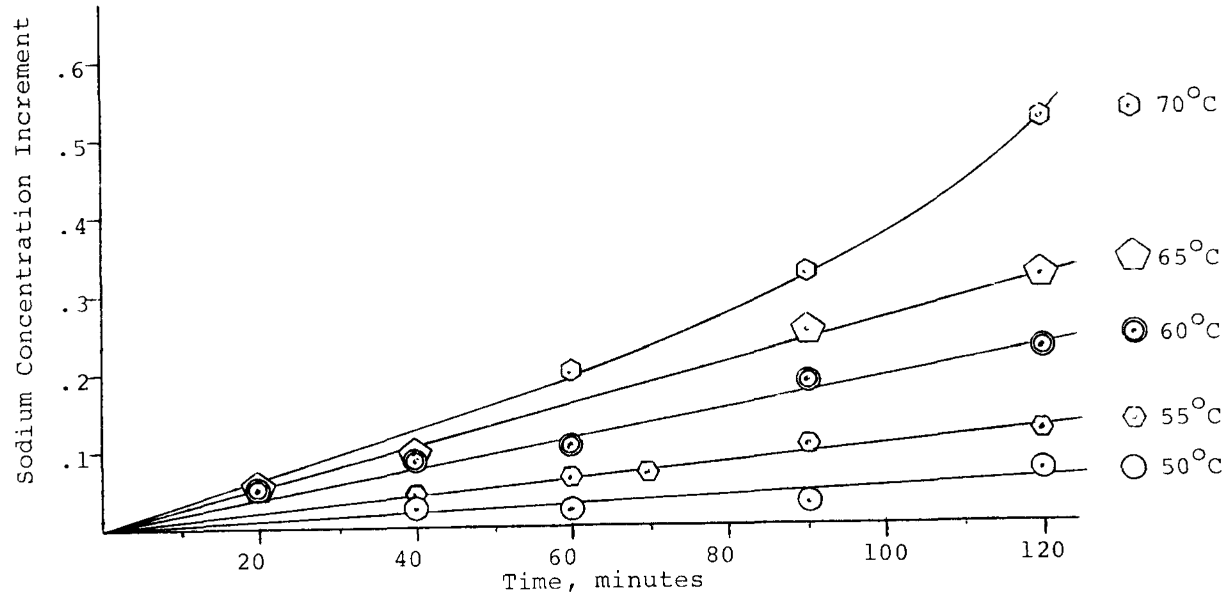


FIGURE 4. DETERMINATION OF SODIUM PERMEATION RATES ACROSS A COATING SYSTEM OF 1 MIL POLYVINYL HYDROGEN PHTHALATE UNDERNEATH A 2 MIL COATING OF "ELVACITE 6014". ONE COATED ROD OF SODA GLASS (3mm DIAMETER, AT 1 INCH IMMERSION) WAS USED IN AGITATED 200 CC RESERVOIRS OF AQUEOUS $Ba(OH)_2$ AT pH 10.7. AT THE HIGHEST TEMPERATURE SOME DETERIORATION OF THE COATING IS EVIDENT, DUE TO LONG-TERM EXPOSURE TO ALKALINE SOLUTION, AS SHOWN BY CURVATURE OF THIS ONE PLOT.

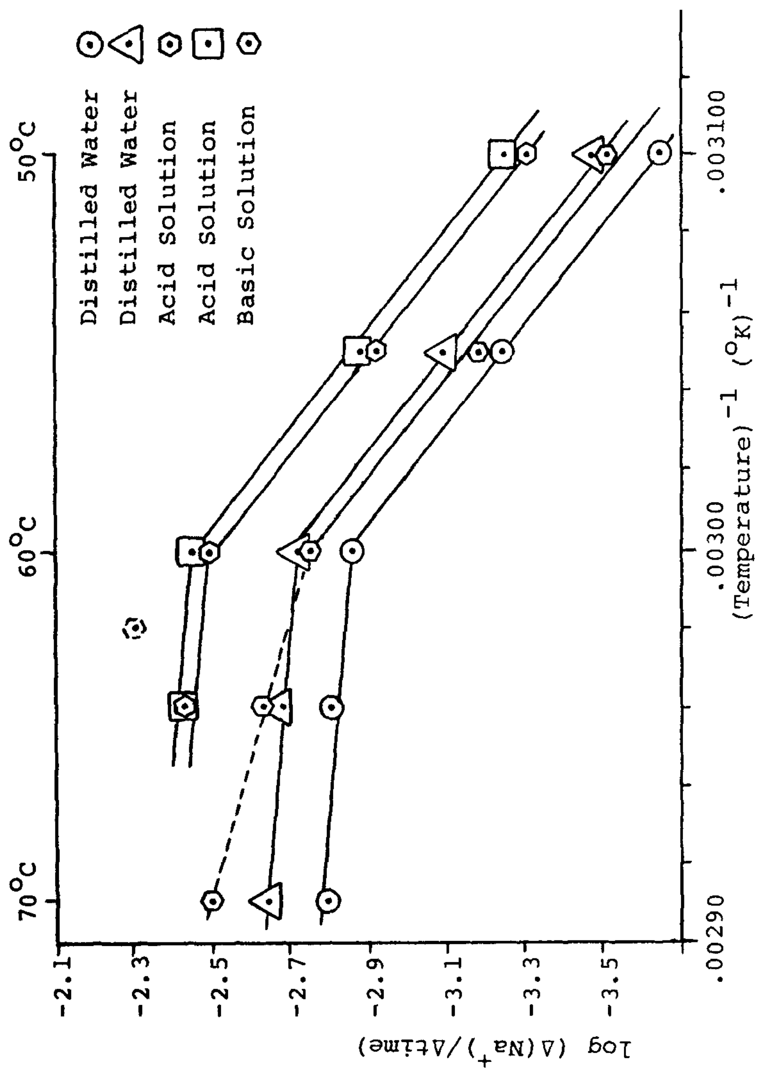


FIGURE 5. ARRHENIUS PLOTS SHOWING SODIUM PERMEATION RATE ACROSS THE COATING SYSTEMS AS A FUNCTION OF TEMPERATURE AND SOLUTION pH. IN ALKALINE MEDIA AT HIGH TEMPERATURES THE PERMEATION RATES ARE NOT REPRODUCIBLE DUE TO DETERIORATION OF THE COATING.

value for the activation energy. In the higher temperature range it was found that the alkaline medium was effective in damaging the coating system, and the activation energy for the coating in the rubbery state could not be determined with any comparable certainty. However, no great loss is incurred, since no end use applications in this temperature range are to be contemplated.

The low temperature data from the Arrhenius plot are suitable for extrapolation into the temperature range of actual use for the coating system, i.e. to room temperature and below. According to experience with many polymer systems, one does not expect to encounter any further discontinuities in the curve at temperatures below the glass transition. Rather one would expect linearity to prevail on this plot, in conformity with the fundamentals of permeation kinetics. Finally, one can calculate that our best estimate of the permeation rate at 25 $^{\circ}C$ would contribute 5.5×10^{-5} g glass/year per cm^2 of surface, under steady agitation. This permeation process would only introduce a few parts per million of sodium into the container contents in the course of an anticipated shelf life of a year.

The Arrhenius plot can be employed in correlating our accelerated immersion tests to the long term permeation phenomena at room temperature. At elevated temperatures it was possible to speed up the permeation process to the point where atomic absorption measurements can detect a reliable rate. However, such accelerated testing is only informative if testing is performed at temperatures below the attainment of the rubbery state within the coating.

The described polymer coating systems stand up well under accelerated testing. No tendency has been detected for the coating to blush or craze, and a continuous coating has no tendency to come loose from its solid substrate. The actual long-term durability of the coating system is presently under investigation.

SURFACE MODIFICATION OF SODA GLASS USING INORGANIC REACTANTS

Various approaches have been employed to alter the surface of soluble glass by reaction with inorganic salts. Such procedures can potentially attain insolubility of surface layers without producing conspicuous changes of appearance or gloss with the glass objects. Any broken object of the desired structure would be almost completely soluble, without leaving any polymer residue. But shatterproofing may not be accomplished as readily as by application of a polymeric coating.

Some efforts are under way to modify the glass surface by ion exchange, i.e. by immersion into aqueous salt solutions that contain ions other than sodium. Various salts have been employed, and it seems that the sodium ions can readily leave the glass surface, and other metal ions can then be substituted into the surface structure. These processes have succeeded in positioning into the glass structure ions of the following metals: magnesium, calcium, zinc, copper, tin, and nickel. These metal ions seem to form layers of silicates that are insoluble, and rates of sodium permeation across the formed layers have been found to be decreased substantially. However, no completely satisfactory surface insolubilization has been attained so far by the exclusive use of this ion exchange technique.

At the present time it appears to be particularly promising to perform ion exchange with cuprous chloride solution and then - after drying - to follow up with a surface "dealkalization" step. The latter procedure involves deposition of a strong acid, such as SO_2 or SO_3 in gaseous form. The procedure is sure to neutralize any alkali that may reside on the glass surface, but it may conceivably involve a change in oxidation state of the metal ions which became positioned at the surface by the ion exchange procedure. The latter mechanism may enable the cuprous ion to become a complexing agent in the oxidized state; and a complexed, insolubilized layer can thus be established at the surface as a barrier between glass and any aqueous phase brought into contact with it. The dissolution of soluble glass across this barrier will produce a basic solution, and phenolphthalein indicator can then be used to demonstrate the effectiveness of the barrier preparation. Such testing has shown qualitatively how the untreated glass material allows the basicity in solution to increase, while no color change in the indicator comes about with samples of the surface-treated glass. Testing methods of a more quantitative nature are being employed currently as an aid to the development of effective surface treatment methods.

INORGANIC COATINGS APPLIED BY VAPOR DEPOSITION

Other research methods have aimed to lay down inorganic barrier coatings on top of the soluble glass by exposing the latter to suitable vapor streams. The procedure is carried out with a special apparatus (see Fig. 6) that allows a decomposable liquid to be introduced into an inert gas sweep, and finally the vapor is decomposed in a heated zone around the object to be coated. If liquid tetraisopropyl titanate is used as the vapor, one can thus deposit a thin coating of titanium dioxide. Alternatively, one can employ ethyl orthosilicate or ethyl triethoxy silane in this procedure to yield a coating of SiO_2.

Since the glass must be heated during the coating application, it is difficult to obtain the coating in an unstrained state (see Fig. 7); for the expansion coefficients of the glass and the coating do not match precisely. Other difficulties with the process arise because the vapors may deposit films of different thickness at various locations,

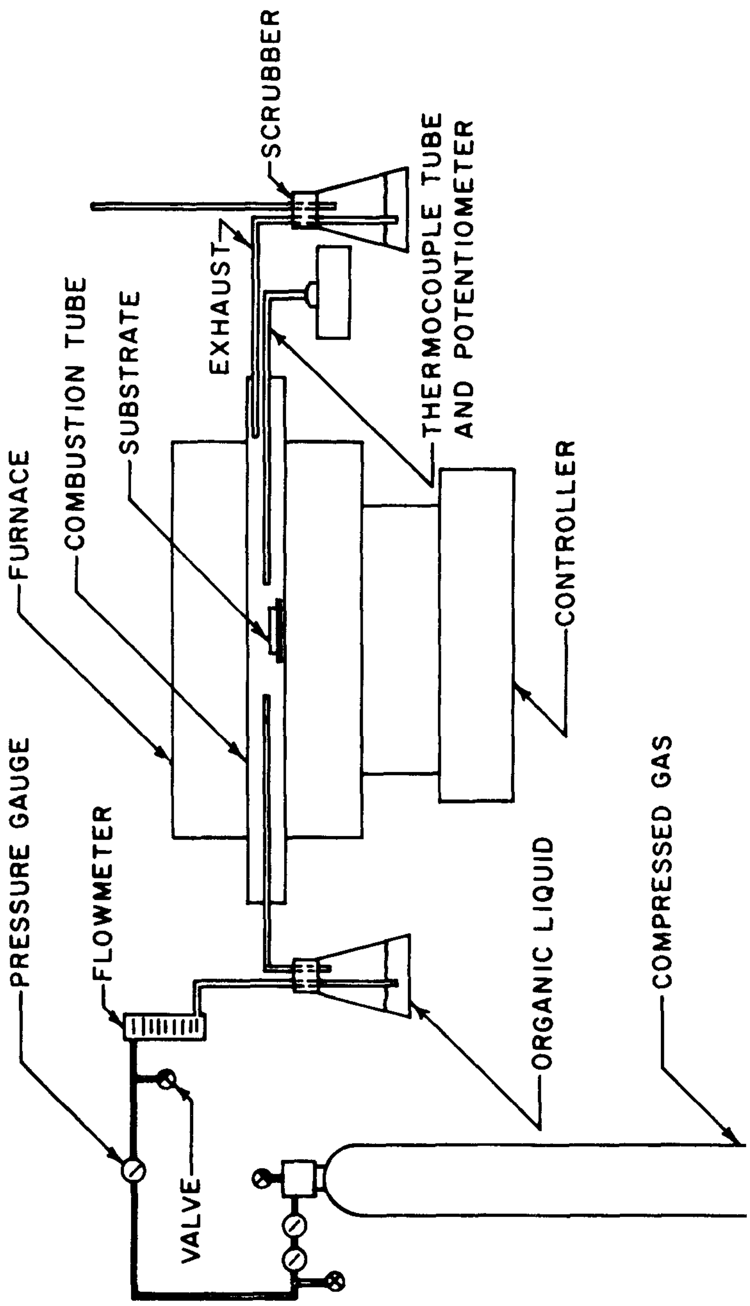


FIGURE 6. SCHEMATIC OF THE CHEMICAL VAPOR DEPOSITION APPARATUS.

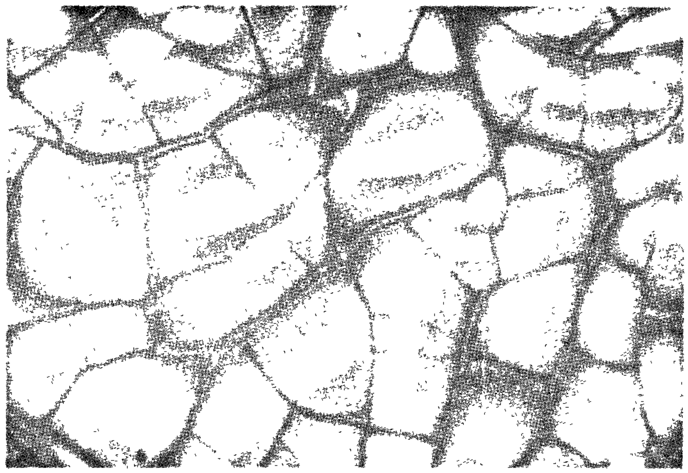


FIGURE 7. PHOTOMICROGRAPH SHOWING RESIDUAL STRESSES IN A TiO_2 DEPOSIT. COATING WAS PREPARED BY BUBBLING N_2 AT 212°F FOR 15 MINUTES AT 8 cfh. DEPOSITION AT 4 INCH DISTANCE, AT 780°F. VERTICAL WIDTH OF DIAGRAM CORRESPONDS TO ABOUT 250 MICRONS.

and orientation of the sample with respect to the vapor stream was found to be very critical. Nevertheless, the deposition rate was found to be linear with vapor concentration (see Fig. 8) and essentially linear with respect to deposition temperature increases (see Fig. 9).

The deposition process is affected by many variables such as sample orientation, sample distance from the nozzle, sweep rates and vapor concentration within the sweep, sample temperature, etc. In particular, it has been noted that TiO_2 coatings turn out to be crystalline above a process temperature of 630°F, and below this limit an amorphous coating will be obtained (see Figs. 10, 11). The crystalline films are inferior, since the grain boundaries are potentially sites at which mass transfer can take place, when the coated structure is brought into contact with an aqueous medium. Small samples bearing amorphous films have been found to be quite acceptable in simulated end use, but no detailed investigations have been performed yet with glass objects that resemble actual containers.

ACKNOWLEDGEMENT

This work was supported by a research grant from the Environmental Control Administration of the U. S. Public Health Service.

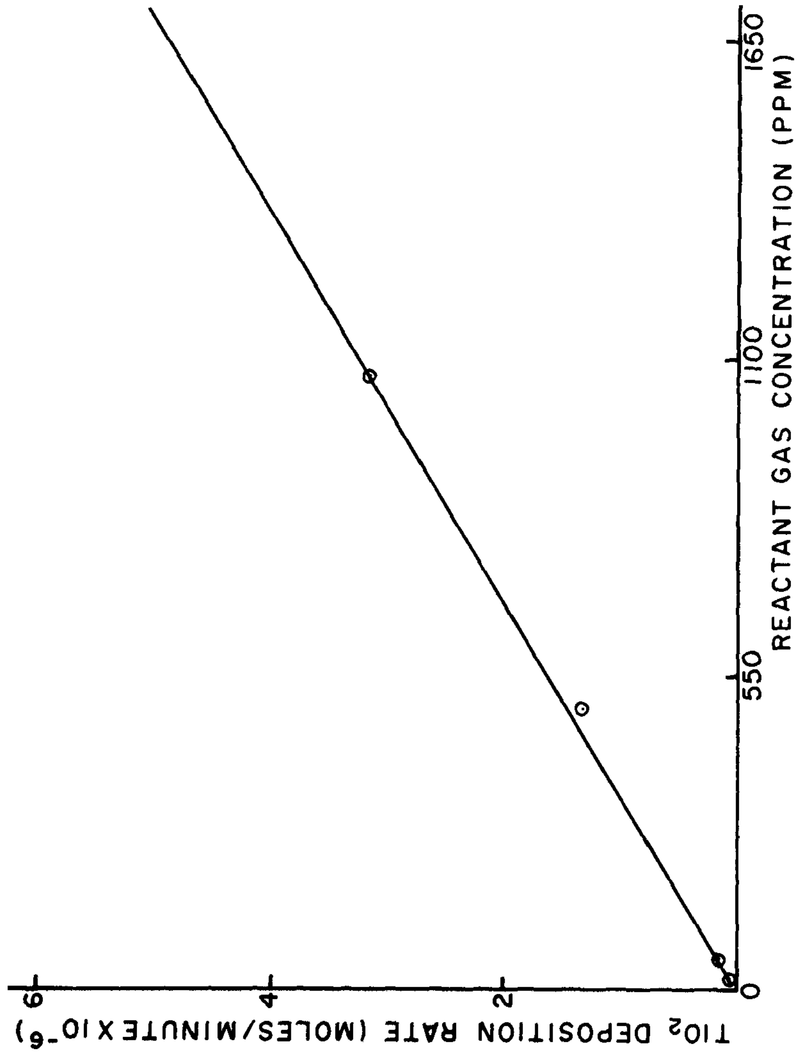


FIGURE 8. TiO_2 DEPOSITION RATE AS A FUNCTION OF REACTANT VAPOR CONCENTRATION. DEPOSITION FOR 15 MIN. AT 780°F, USING CARRIER GAS FLOW OF 8 cfh. IMPINGEMENT DISTANCE WAS 4 INCHES.

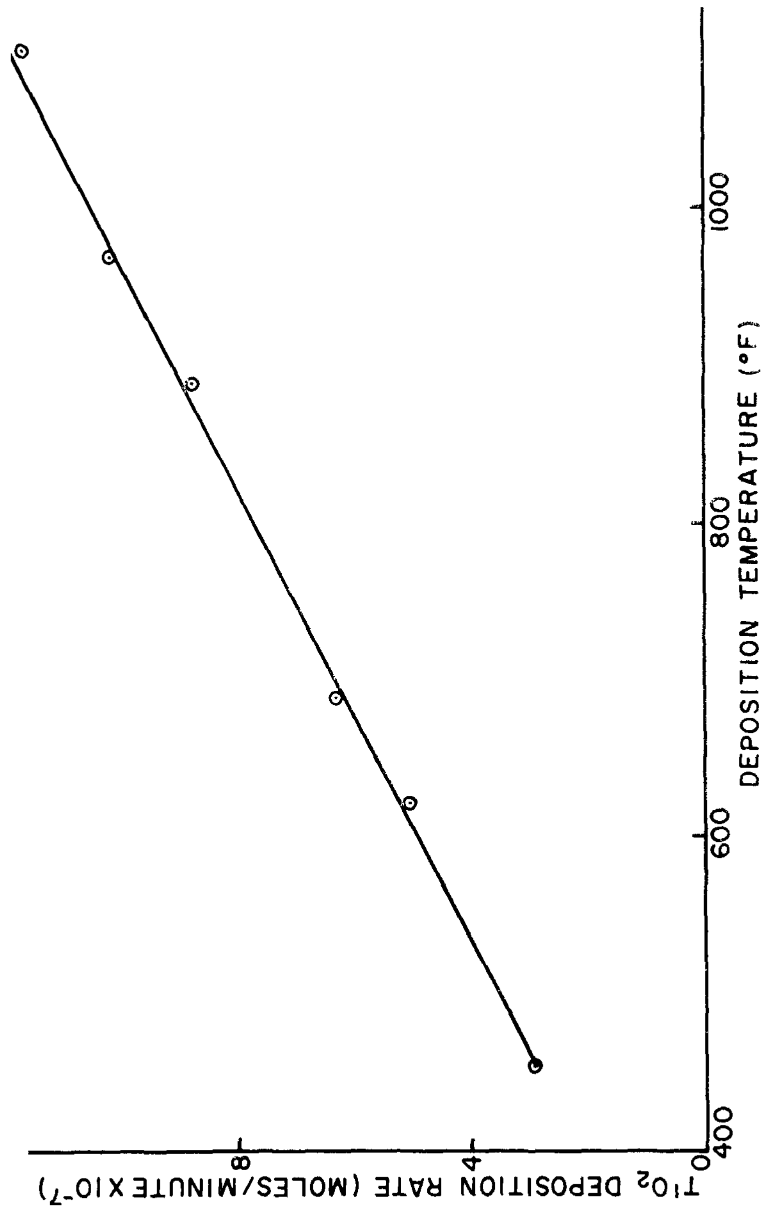
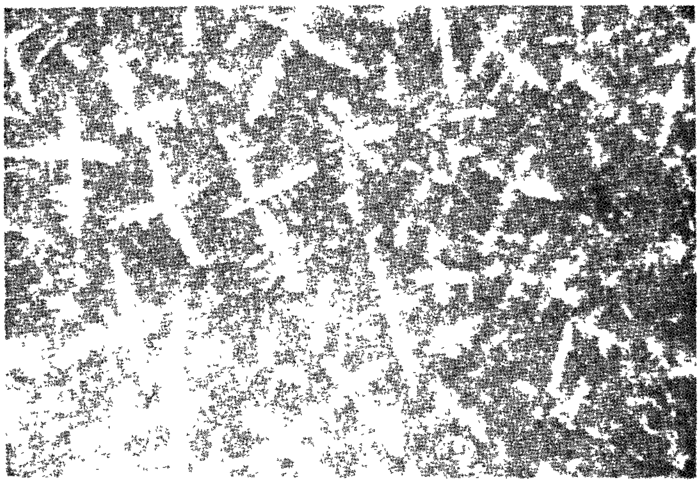


FIGURE 9. TiO_2 DEPOSITION RATE AS A FUNCTION OF DEPOSITION TEMPERATURE. DEPOSITION AT 4 INCH DISTANCE FOR 60 MIN. AT 10 cfh SWEEP RATE.

A



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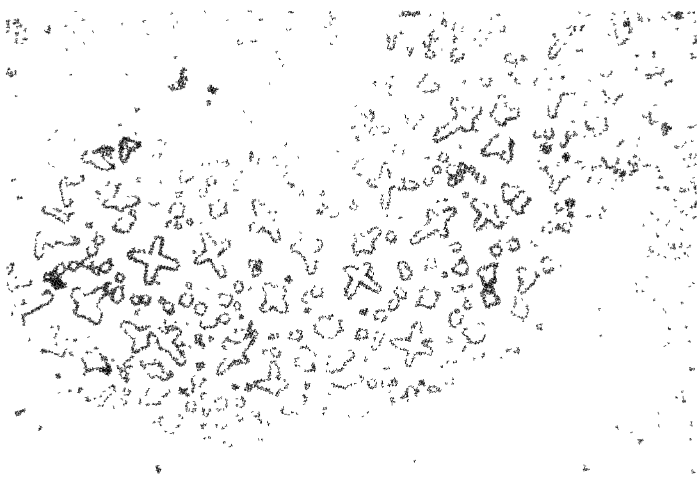

FIGURE 10. PHOTOMICROGRAPHS OF TYPICAL SECONDARY STRUCTURE IN CRYSTALLINE TiO_2 DEPOSITS. (A) DENDRITES, (B) CROSSES. VERTICAL WIDTH OF THE PHOTOGRAPHS CORRESPONDS TO ABOUT 250 MICRONS.

FIGURE 11. PHOTOMICROGRAPH OF SURFACE TOPOGRAPHY ON TYPICAL AMORPHOUS TiO_2 FILM. THE COATING HAD BEEN CRACKED INTENTIONALLY TO SHOW DETAIL. VERTICAL SIZE OF PHOTOMICROGRAPH CORRESPONDS TO ABOUT 350 MICRONS.

COMPOSITE BOTTLE DESIGN AND DISPOSAL

Philip Williams
Owens-Illinois, Inc.

The glass container industry has made packages for many different industries from small perfume bottles to five gallon water jugs. The inherent flexibility of our manufacturing process has allowed us to make many distinctive and unique items. Our business, like most others, has changed over the years, especially in those end uses that are most important to us. New competitive containers and outside forces, such as legislative, have created dramatic shifts in our business. The prohibition era, of course, affected our beer and liquor ware business drastically. More recently the switch to plastic packaging has virtually eliminated bleach bottles and liquid detergent bottles from our sales. Ours is an ever changing business and our marketing and research people try to focus on where our business is going and what the new needs will be.

In the middle 1960s, any evaluation of the future of the glass industry resulted in the conclusion that the growth areas of beer and soft drink packaging were going to be really exceptional. We, therefore, made an evaluation of our present flexible manufacturing process to determine whether it was going to be able to keep up with this growing demand. At that time, the inputs of the environmentalists were relatively low key. We decided to design and develop a new standardized package to meet the growing demands of the beverage industry. The result of this Advanced Systems Development group was the GCP or glass composite package.

As our development emerged, we factored in the recycling concept. We will cover the recycling of the GCP package in greater detail later on but let us say that we do not see any major problem in fitting it into our glass recycling programs.

We are also going to discuss a new glass composite package that was announced only April 20, called Plasti-Shield. This package has been developed within the last eighteen months and from the very beginning the environmental aspects have been important inputs on our design. I will discuss it later in some detail so that you can be familiar with its attributes. Therefore, we would like to use these two new packages as examples of how package design can be melded with constraints such as disposal.

The GCP (glass composite package) is an important part of a total system that Owens-Illinois is developing to supply the growing needs of the beer and beverage industries. We intend to supply soft drink and beer customers a totally new package, designed specifically for them, for 10 to 16 ounces of their product to compete with the standardized can. GCP consists of a lightweight glass globe seated in a plastic base which can be colored and preprinted. The glass walls are thin and the design provides a widemouth drinking lip, plus convenience closure. The GCP utilizes basic low cost but recyclable raw materials, glass and high density polyethylene, in a very sophisticated way. (The glass globe is an ideal pressure vessel and will both contain and preserve the product and its flavor. The plastic base acts as a coaster and provides protection and identification.)

The choice of polyethylene as the base material resulted from a complete screening of all possible plastic and metal materials. The rigidity of the high density polyethylene to support the plastic base was essential to the concept, but the fact that it is also a nontoxic material when incinerated was also important. The design of the glass globe, which is a nearly perfect pressure vessel (both the products have internal pressure requirements) allowed us to reduce the glass weight dramatically. For example, on a 10 ounce package, the glass weight is approximately 2-3/8 ounces compared with a minimum of 7 ounces on soft drink packages. We have indicated the function of the plastic base earlier and we feel it definitely enhances the durability of the package.

As the <u>second part of the system</u>, we have developed a totally new manufacturing process. It consists of a ribbon glass machine and five auxiliary machines. Attributes of the new process are high speed, good efficiency, consistent quality, and low labor content.

Early in our development, it was apparent that we needed the third component of the system - a packaging line to match the efficiencies of can lines and preserve the total economics of glass packaging. We, therefore, set out to develop a customer packaging line for handling glass at high speeds and efficiencies.

In taking the total systems approach, one must of course be aware of the disposal of the package too. We are developing answers to the disposal of the GCP as well.

During the past three years, we have conducted a number of marketing research concept tests to evaluate all variables of the GCP concept. The key finding of all the marketing research, we feel, is that almost without exception among beer and soft drink users, the GCP package produces a favorable response. There are many apparent consumer benefits. For example, the consumer likes the wide mouth because GCP is easy to drink from and they perceive the plastic base as a "coaster" that will prevent moisture rings from forming under the bottle.

An important part of our development program is to continually test the package performance in all of its aspects - technical and consumer particularly. Careful screening and testing is the only way to prevent putting a product on the market that has serious flaws.

We are at a point in our development where we must take another important step. This summer we will put the 10 ounce GCP, containing cola products, into the consumer's home and have it used in real life conditions. Providing there are no major problems encountered, we plan to move promptly into selected stores in certain markets for longer term testing later this summer.

At the present time, our pilot production and development center in Toledo is still in the development and refining stage. Barring any unforeseen difficulties, we hope to be commercial late in 1973. Once we have proven the ribbon process for beer and beverage containers, we will begin to investigate other potential uses such as fruit juices, premixed cocktails, infant formula, etc.

Now I would like to detail for you the Plasti-Shield package which we mentioned earlier. This package is made on our conventional forming equipment but is lighter in weight due to its design, (like GCP it is a pressure vessel basically) and has a foamed polystyrene jacket shrunk onto it. This package will be offered commercially to our customers in September of 1971 and is currently in in-home placement and market testing with three major soft drink companies. The plastic sleeve or jacket allows us to substantially reduce the weight of the glass packages in the 16 ounce and family sizes. For example, the quart soft drink package has over 7 ounces less glass than standard quart nonreturnable glass containers. Weight reductions in the smaller sizes are significant but not as great. The choices of plastic materials that will shrink and adhere to the glass envelope are many but again we have tried to choose materials that are both functional and yet not inherently a major disposal problem. The foamed polystyrene protects the glass from abuse and makes this weight reduction possible, therefore, we are dealing with a package that has substantially less solid waste problems.

When commercialized, considerably less multiwrap materials will be required and inner packaging on family sizes can be eliminated thus cutting down the packaging materials required to market each gallon of soft drinks or barrel of beer. By adding the polystyrene to the package, we have raised some of the same questions in your minds, I am sure, that exist with the polyethylene base on the GCP container. We feel that the answers to the disposal of both these packages are quite similar and that they are just as recyclable as conventional glass containers. We will go into this reasoning in just a moment but first we would like to touch on the litter and solid waste aspects that we feel are applicable to the glass container industry as a whole.

We are dealing with convenience packages for beer and soft drinks which are high on the list for legislative action. There are both litter and solid waste ramifications and being new and highly publicized containers, our profile will be high as we approach commercialization. Let's first put the problems in perspective.

The present distribution systems for beverages have been established by both industries at a significant investment with the objective to get products to the consumer at the lowest possible cost. These systems are now based primarily on convenience packages. For example, approximately 75 percent of packaged beer is in convenience containers and 50 percent of soft drinks; and these figures are continuing to grow. It can be factually documented that convenience packaging has directly contributed to the substantial growth of both the beer and soft drink industries. More people are enjoying them because they are easier to buy and use.

Any interference in the natural flow of these systems will lower the efficiency and increase the costs to the consumer. The lack of understanding by the general public of these distribution systems and the concern by the public about the environment have resulted in increasing pressure for legislation to ban convenience packages.

Even though their products represent only a very small percentage of litter and solid waste, the beer and beverage industries are being singled out as exceptional problems. Because roadside litter is a visible, irritating form of consumer-generated pollution, the problems surrounding its existence are obviously more publicly discussed.

We are convinced that the ultimate solution to the litter problem is through public education like KAB's programs starting with our children in the very lowest grades. We repeat that education, coupled with enforcement of realistic laws against littering and provision of adequate disposal and collection facilities represents the only practical solution to the litter problem.

We believe that the ultimate solution to our solid waste problem must be the salvage and reuse of much of what is now deemed waste. Actually, we make a value judgment by the name we assign to our discarded materials. We call them solid waste. It seems to us that we must turn this around and call them solid assets or resources that can be reused. The conservation of raw materials demands salvage, and long range efficient management calls for the reuse or recycling of many of the components of waste. We are convinced that salvage and reuse will materially reduce pollution and conserve our finite resources.

The recyclability of glass containers has been well established. There is nothing new or novel about reusing glass containers, as cullet has been an important raw material in glass manufacturing for hundreds of years. This group, here today, certainly is aware of the work that is going into devising methods of allowing us to obtain glass waste. This is the major problem today, not what to do with it after we get it. In our thinking, primary recycling is getting our glass materials back into our hands so that we can make another glass container with it. Secondary recycling is devising other uses for the recycled material and, here again, I am sure most of you are aware of the programs in this area such as described by Dr. Ward Malisch from the University of Missouri at Rolla.

The separation of glass from the waste cycle can be accomplished at a number of points in the disposal system. We see consumer separation and reclamation as now being practiced at the over one hundred centers sponsored by the GCMI as one possible route, but in our long range thinking we believe systems which can separate mixed collected garbage, such as Black Clawson's Hydrasposal system or the Bureau of Mines project to be the real answer. We are convinced that since we have such a recyclable material, practical and economic methods are being devised to assure the reuse of glass over and over again.

Now, how do the two packages fit into the environment? We feel that the possibilities for recycling both of these packages are very similar so we will deal with them together except where there are obvious differences.

First, let's consider primary recycling. We have made a number of tests on the technical feasibility of melting the entire package - glass and plastic - in our furnaces. It appears from these tests that we can use up to 10 percent of this product in our flint melts without discoloration and up to 50 percent in our amber melts. Both polyethylene and polystyrene will burn off at our melting temperatures with the resultant dispersal of CO_2 and water into the atmosphere. We feel it is unlikely that we would get large quantities of either package back in the early stages of development, so the percentages mentioned would seldom be reached as cullet. However, should our collection system change so that large quantities of either package were accumulated, separation of the glass and plastic materials would then be undertaken. Crushing and floatation very simply separate the two materials. We plan to use this process in our own plants on off-ware as a matter of course.

In secondary recycling of the packages, we are talking about end uses which could combine the glass and plastic materials into useful products. To develop good economics, it is essential that you require only a crude sort of the package from other solid waste materials - that is, there does not have to be a high degree of efficiency in the sorting system, and there can be room for error. By developing the right end uses, the reuse application might permit the complete range of glass colors to be lumped together, as well as all thermoplastics. This would make segregation much simpler and practical. It would be highly desirable if, for example, conventional glass containers, GCP, and plastic bottles could be included as a segregated commodity in the collection system. A corollary of this first consideration is that the materials one makes from the recycled packages should not have highly demanding technical specifications as to colors, physical properties, etc. To make useful products that fill high volume needs, the end product must have good utility, but appearance should not, if possible, be of great import. This does not mean that the product could not be made to satisfy utilitarian needs, but what we do mean is that products that rely on a close control of color, texture, or sophisticated physical properties should not be considered.

We have experimented with ground up GCP packages, extruding into a molded glass-plastic material. The kinds of products we visualize being made from this glass-plastic combination must necessarily be high volume uses, therefore, we are considering such products as tier sheets for our pallet loads, cap sheets, possibly pallets themselves, and reshipper trays and cases. Being able to utilize this recycled material in our delivery system to our customers could be of definite economic advantage to all of us. Other high volume needs are being investigated too.

If we visualize the manufacture of this composite material at one of our GCP facilities, we could work any unbalance in glass-to-plastic ratio quite easily if we kept, for example, our own scrap segregated by glass and plastic fractions so that either ratio could be corrected in our mixing operation. The separation of the polystyrene sleeve from the Plasti-Shield package is even easier than with GCP. The polystyrene sleeve material could be reprocessed into products that are basically nonfood use intended. This is already being accomplished today in the development of coffee cup lids which are an "ecology buff" in color and made from recycled material. The polyethylene base originally designed for GCP package must be made from virgin material. We are examining very closely another design concept for the base which is a direct result of our endeavor to fit the package into the recycling system. This new design, which I am going to explain to you, is really only in the feasibility stage but I felt it was important enough to brief you on it today.

We visualize the possibility of utilizing a polystyrene sleeve similar to the one used on the Plasti-Shield package. I think you can visualize that simply wrapping the sleeve around the GCP globe would make a very unstable package. We are testing, at this time, a concept of seating the globe in a doughnut made from recycled glass-plastic materials and then shrinking the sleeve around it. Here is what the package might look like. This doughnut support base is made from extruded glass-plastic recycled materials. It is too early to determine the complete economic and technical feasibility of this concept but we did want to share it with you today.

While the separation from mixed garbage of the recyclable materials is, of course, the ultimate answer, we are going to have to live with less than perfect solutions for sometime to come in many urban waste disposal systems. The combined glass-plastic waste of GCP and Plasti-Shield can be disposed of in incineration or land fill with no particularly obnoxious results.

It is clearly apparent to us from discussions with our major customers that the litter and solid waste problems are of critical importance to GCP and Plasti-Shield. To have successful projects and to really provide our customers with a total systems approach, we must have satisfactory answers to these problems.

I have covered a lot of material in this period allotted to me and we have not been able to go into all the ramifications of these two packages in as great detail as I would wish. However, I think it is apparent that the design of both of these new packages has been affected by the new environmental emphasis and we hope that you will agree that these two products can make some real contributions to this problem.

SEPARATION OF GLASS FROM MUNICIPAL REFUSE

R. J. Ryder, Brockway Glass Company, Inc.
J. H. Abrahams, Jr., Glass Container Manufacturers Institute, Inc.

INTRODUCTION

Environmental pollution--and its control--has been a concern of the glass container industry for many years. As long ago as 1953, before the problems of litter and solid waste generally were recognized as threats to the quality of life in our environment, the Glass Container Manufacturers Institute and its member companies were instrumental in the founding of Keep America Beautiful, Inc., the national litter prevention organization. Since that time, the glass container industry has continued to furnish significant financial and service support to KAB for its various education and litter law enforcement programs. Four years ago GCMI broadened its environment-oriented activities by establishing an Environmental Pollution Control Program in order to seek solutions to problems related to solid waste management and air and water pollution. We believe we were one of the first industries in America tu organize programs of solid waste management and litter prevention on an industry-wide basis.

Today's discussion, however, will deal only with the role of glass containers in solid waste and the pertinent programs and research currently being sponsored by the glass container industry. Recent studies show that glass constitutes an average of about six and one-half per cent by weight of municipal solid waste. Of this, about five per cent comes from container glass. In fact, according to a study by the Midwest Research Institute, all packaging accounts for only about 13 per cent of total municipal (residential and commerworking to reduce or eliminate such problems as may exist. It is important to understand that utlimately a discarded glass container can meet only one of three possible fates:

SEPARATION AND RECYCLING

Recent studies have shown that there are potential uses for every bit of waste container glass available in the country now or in the foreseeable future. As a first step in the direction of total salvage and reuse of waste container glass, the nation's glass container manufacturers are conducting an industry-wide reclamation and recycling program.

Today GCMI member companies are operating a network of nearly 100 bottle reclamation centers in some 25 states. Since the program was inaugurated on an industry-wide basis on June 30, 1970, many tons of glass containers have been salvaged from solid waste and litter. These salvaged bottles, now being reclaimed at a rate of close to one-half billion a year, are being recycled back into the bottle-making process.

Reports by member companies indicated that crushed waste glass, called cullet, can provide 30 per cent or more of the industry's raw material requirements. Our bottle reclamation program is able to supply only a small portion of this amount. Therefore, in order to obtain salvaged glass in greater quantities, GCMI is cooperating with various research organizations and federal, state and local government agencies to develop efficient, low-cost, highly automated systems for separating the components of raw refuse.

One example is at Stanford Research Institute, where GCMI and the U.S. Environmental Protection Agency sponsored investigation of a process known as the Zig-Zag Air Classification System which utilizes forced air currents to separate refuse materials into its components. To date a major separation of paper and plastics from heavier matter has been achieved. Samples containing between 75 per cent and 90 per cent glass have been obtained readily from the heavier fractions. Further separation, however, becomes more difficult because of the similarity of densities of materials in the heavier fractions. More work is needed to test the efficiency of separating waste glass for metals, but the outlook for this research appears promising.

The industry is working also with various organizations to further refine glass from these preliminary processes for recycling in glass furnaces. To this end GCMI is supporting studies at the Sortex Company at Lowell, Michigan to optimize the means of optically sorting the glass that has been reclaimed from solid waste into its various colors. On a pilot basis this research is producing color-sorted glass of a quality that can be recycled by our industry. When perfected, it will enable glass container manufacturers to consume large tonnages of salvaged glass.

Further, we have been following and working closely with the U.S. Bureau of Mines on its development of a process utilizing standard ore dressing methods to separate usable materials from incinerator residue and high-intensity magnetic forces to sort glass by color. The Bureau estimates that after the salvage of metals the separation of clear or flint glass costs only an additional 77 cents a ton, using figures for its 250 tons-a-day plant. From a practical standpoint, the potential benefits are enormous. Sorted by color and refined, glass from incinerator residue could be used as cullet to make new bottles or used in secondary products.

Also, a number of solid waste management systems are presently in various stages of development by private industry. Some, in fact, need only the opportunity of a full-scale demonstration in a typical community to prove their worth. One such development, which will be discussed in more detail later in this presentation, is a unique wet system capable of crushing and separating paper pulp, metals and glass from other materials at a reported cost of approximately $3.60 per ton of raw refuse after allowing for pulp and ferrous metals salvage. This includes operating costs and amortization in a plant designed to handle 500 tons of waste a day. This system is being constructed at Franklin, Ohio by the Black Clawson Company with the assistance of a demonstration grant from the Solid Waste Management Office of the U.S. Environmental Protection Agency.

SECONDARY MATERIALS

We define secondary materials as those products other than new glass containers that are made from waste glass. GCMI's research on secondary materials has been directed largely toward determining those products which can incorporate waste container glass which is not sufficiently refined to be used in glass manufacturing furnaces. Generally speaking, these secondary products are in the nature of construction materials where the glass must compete with relatively cheap raw materials.

For example, GCMI and the Environmental Protection Agency for several years have supported studies at the University of Missouri at Rolla which show that glass fragments may be substituted for stone aggregate in glasphalt, one of the better known potential secondary products. But the cost of stone aggregate averages around $2 to $4 a ton. In this case it would not be practical from an economic standpoint to pay processing costs in excess of $5 or $6 a ton for the waste glass alone. However, the cost for processing the refuse mix must be distributed proportionally among all of the salvageable components. This approach must be considered for both the Black Clawson system at Franklin, Ohio as well as for the U.S. Bureau of Mines incinerator residue reclamation system at Edmonston, Maryland.

Intitial calculations indicate that glasphalt alone could use up all the waste container glass available in municipal waste systems now and in the forseeable future. Estimates for waste container glass in refuse today range between 10 and 15 million tons annually, whereas the amount of stone aggregate used in asphalt approaches third of a billion tons annually. If waste glass were to be substituted for even three or four per cent of the aggregate, all the glass still would be utilized.

Furthermore, GCMI is funding a study at the University of Missouri at Rolla which will evaluate the amount of foreign material which could be tolerated in glasphalt. If a certain amount of metals and organic materials could be tolerated, then less processing of municipal wastes from proposed mechanical separation systems would be needed and the costs reduced.

Another well known secondary product utilizing waste glass is the brick made from glass-enriched incinerator residue. In the U.S. Bureau of Mines process of removing metals for recovery, a mixture containing some 98 per cent glass is left over. This product can be used directly for making bricks using various binders, such as 10 to 30 per cent of regular brick clay. In general, regular brick making equipment can be used.

In addition to these products, GCMI and its member companies have been conducting studies of some 10 other secondary products which are made from waste container glass.

In one process bricks using waste container glass can be made by using high pressure and cement, and certain chemicals such as those developed by the T-A Materials Company. These bricks can be made to such close tolerance that a paste material can be used instead of standard mortar. With this system various shapes of bricks and blocks can be designed.

Blocks and bricks -- even large panels -- can be made by a variety of other processes. Studies with GCMI support are being conducted by the Colorado School of Mines Research Institute to use waste container glass as the binding medium for panels 4 feet by 16 feet and up to 4 inches thick. The composition is 6 per cent clay, 13 per cent to 94 per cent glass and 0 per cent to 81 per cent rubble, yielding a bulk density of 130 pounds to 140 pounds per cubic foot depending upon the proportions used. The crushing strength was found to be as high as 12,000 pounds a square inch. Panels containing the higher glass ratio can be polished for decorative effect.

Stanford University is conducting studies using glass and silica with cement and other materials to make an expanded or porous material for insulated wall panels.

Furthermore, glass wool insulation can be manufactured using up to 50 per cent waste glass. This is being done by the U.S. Bureau of Mines using glass recovered from incinerated residue and by at least one commerical manufacturer. The Bureau is also making such other products as glass beads and lightweight aggregate from glass rich incinerated wastes.

In the case of the bricks, blocks, and wall panels, each use could easily absorb the waste container glass in a municipality. Preliminary studies show that many of these products using waste glass could compete with standard construction materials if separation systems were utilized and markets developed.

In California, standard 5/8-inch terrazzo flooring has been developed which itilizes reclaimed glass in place of marble chips. In addition to the regular flooring thickness, a second type, also using waste glass but featuring a new matrix, has been created by the American Cement Technical Center. By incorporating small amounts of a polymer substance into the product mix, the company has been able to produce a terrazzo finished to a 1/4-inch thickness with two or three times the flexible strength of normal terrazzo. This new product provides a significant weight saving which can be a major factor in high-rise buildings.

WASTE DISPOSAL METHODS

As we have already indicated, glass containers contribute only a small portion of the solid waste mix. However, if glass is properly ground for disposal in sanitary landfills it returns to the soil in almost its original form and the volume is reduced substantially.

The Institute has sponsored independent studies to determine the degree to which glass containers constitute a solid waste problem. These studies have indicated that waste container glass, when properly handled, is not a problem in present municipal disposal systems.

In solid waste landfills, for example, Drexel University determined that glass does not contribute to any physical problems or chemical pollution. When crushed or ground, glass mixed with the soil becomes a permanent and firm fill which will not settle or erode. In addition, there is virtually no leaching from the glass to cause pollution of ground and stream waters.

Similarly, and despite widespread views to the contrary, glass has not been found to be a significant problem in incineration. Glass containers generally break into fragments due to the heat blast in incinerators. Many of these fragments help aerate from the batch and thus enhance combustion, while other fragments fall through the grates.

According to data collected in a recently completed national opinion survey of municipal, county and solid waste management offifials, glass containers were found to be among the least difficult of all packaging materials to handle in refuse collection operations. This study was conducted by the Resources Management Corporation of Bethesda, Maryland, in order to determine directly from officials responsible for solid waste collection their views on the role of packaging materials, particularly glass containers.

Among other things, the study found that almost 70 per cent of the officials believe that no packaging material is damaging to collection equipment. Only two per cent of the respondents felt that glass containers would harm such equipment and only 8.1 per cent considered them difficult to handle. Further, the waste management officials indicated that glass containers are the least troublesome of all packaging materials in landfills and incinerator operations, falling behind steel, plastic and corrugated containers.

However, in general the refuse systems in most municipalities are inadequate and antiquated. Only recently have municipalities begun to look beyond the garbage man and truck concept of refuse collection. The labor intensive collection systems, in fact, account for 75 to 80 per cent of refuse costs. It is hoped that Federal funds may be provided under the Resources Recovery Act of 1970 to finance projects which will upgrade significantly collection and disposal systems.

LONG-RANGE SOLUTION

Consumer demand has established a market for convenience packaging, and part of the convenience of using such packages is the fact that they can be discarded. The refuse mix must be separated, but we cannot necessarily expect the nation's housewives to do this job.

The nation's glass container manufacturers are convinced that the long-range solution to the presence of glass in solid waste can be found in the separation sytems and markets for waste glass which are currently being developed. These systems are designed to deparate the various salvageable components of refuse, and glass is but one of these. The enriched, mixed colored glass is a by-product left after other materials are separated,and thus it starts with a zero value, or even a negative value since disposal in a landfill could cost several dollars a ton.

As we have seen, two potential markets are developing for this glass mixture. One is the use of waste glass as cullet in the bottle-making process; the other is its use in various secondary products. By using materials handling methods, glass fragments 1/4 to 3/4 inches across can be freed of contaminants and color sorted for remelting and reforming into containers. Less refined or smaller sized fragments are usable in secondary products also. As indicated earlier, the U.S. Brueau of Mines id developing a system using commercial equipment which is capable of separating sand-sized particles by color.

Today there are perhaps three major approaches to separation. These are wet separation, dry separation, and separation after incineration or pyrolysis. The glass container industry is working closely in the development of several of these systems in order to evaluate the quality of waste container glass produced and the potential markets. Systems using one or more of these basic systems are nearing the stage of practical demonstration.

One of the best known systems is the Hydrasposal method developed by the Black Clawson Company of Middletown, Ohio. A prototype of this wet spearation system is being constructed at Franklin, Ohio. When fully installed, this plant will be one of the most complete systems in the country for processing the waste products of our society. The Hydrasposal and Fiberclaim systems, manufactured by Black Clawson, are designed to handle nearly all normal municipal residue except bulky items. Coordinated with this is a modern sewage disposal plant to be built soon by the Miami (Ohio) Conservancy District which will serve Franklin and the surrounding area as well and will process contaminated waste water from the solid waste plant.

The Black Clawson demonstration plant is being designed to handle 50 tons of refuse in an 8-hour day, with a salvage potential over 50 per cent of the total tonnage. The process will first crush the refuse into a liquid slurry small enough to pass a 3/4 or 1 inch diameter opening. Heavy materials settle out, and ferrous metals are removed magnetically. Inorganic materials are then removed in a liquid cyclone, which leaves a residue of heavy materials consisting of 80 per cent glass and nonferrous metals. The light organic portion is reduced into discreet fibers with contaminants screened out.

The glass container industry is interested in the heavy portion containing the 80 per cent glass and has designed a system to refine the glass fraction into a material usable in glass manufacturing furnaces. As such, the glass must be clean, uncontaminated, free of metals, and sorted by color.

The glass subsystem has been designed by GCMI and by the Sortex Company to receive this glass-rich mixture from the Hydrasposal and remove all contaminants before or during color sorting. A prototype of this subsystem is planned for installation at Franklin, Ohio with the funds to be provided by the Federal Environmental Protection Agency and GCMI. Several research methods for removing contaminants will be used, including washing, screening, air optical separation. The initial steps will be to:

1. Receive the mixture and remove strong magnetics.

2. Size to separate the glass into the fractions larger than 1/4 inch and smaller than 3/4 inch.

3. Dry before further processing.

The glass fragments larger than 1/4 inch will be processed further in preparation for color sorting with the Sortex machine, and the smaller samples either removed from the system for use in secondary products, or passed through an air classifier in preparation for an experimental high tension electrostatic separator to remove the clear glass.

In preparation for the Sortex separator, the large fragments (1/4 inch to 3/4 inch) will be subjected to a cyclone air classifier and a zig-zag classifier. These two separation systems will be in service for this experimental subsystem, but the most efficient of the two systems probably would be used in a second generation subsystem. The Sortex optical sorter scans each fragment as it passes through a filtered beam of light and sorts the clear glass from colored glass and contaminants. A second pass of the rejects would then sort the greens from the remaining mixture, until all economically salvageable glass fragments are removed.

The glass subsystem is an experimental unit designed to determine the effectiveness of various separation systems for glass. It is anticipated that the subsystem, with proper modifications, could be adapted to one or more of the several mechanical separation systems being developed.

CONCLUSION

These, then, are some of the steps that have been taken by the glass container industry to help alleviate its contribution to the nation's growing solid waste problem. The utlimate goal toward which we are working is the eventual separation and salvage of usable waste components and their return to industry for recycling.

Hopefully, future generations will see a nationwide network of refuse processing stations, perhaps designed along the order of the Franklin, Ohio pilot project, where municipalities, or even utilities, will separate wastes mechanically and automatically and subsequently sell the recyclable materials to manufacturers or refiners. Such systems, we believe, will result in the much needed conservation of our natural resources and reduce pollution from solid waste.

SESSION IV

METALLIC CONTAINERS

Chairman:

G. R. Smithson, Chief
Waste Control and Process Technology
Columbus Laboratories
Battelle Memorial Institute

FERROUS SCRAP RECYCLING AND STEEL TECHNOLOGY

William S. Story
Institute of Scrap Iron and Steel, Inc.

I am here today representing the ferrous scrap recycling industry. And while members of the Institute of Scrap Iron and Steel also handle non-ferrous metals, my remarks are confined to ferritic materials with emphasis on the tin can--whether all steel or with an aluminum top.

Public concern with the quality of our environment and the conservation of our natural resources strikes a favorable chord with members of the metal recycling industry, especially as it applies to scrap iron and steel. For years, we have been commenting on the need to better utilize our resources, through conservation by recycling, but only now are the words falling on receptive and eager ears, and only now are we seeing action taken which will serve, over the long run, to recycle as much of our ferritic metallics as possible.

As I am sure you are aware, our industry has been responsible for recycling millions of tons of iron and steel scrap annually to steel mills and foundries. However, because of changing technology in steelmaking, the volume we have recycled to steel mills has not kept pace with the rate of discard of items made from steel and iron. Had we continued the high level of recycling which we obtained during World War II, for example, this nation today would have no major metallic solid waste problem. But we have not, and as a result, we do have a problem. And while this is primarily a container program, let me cite some data for you on the overall iron and steel scrap picture in order to bring the matter into somewhat better focus.

If we are to go back to 1956, we find that in that year, the domestic steel industry produced 115 million tons of raw steel, and in the course of this, plus foundry production, our industry shipped 37 million tons of scrap. In 1970, the domestic steel industry produced 131 million tons of raw steel, and purchased scrap sold by the scrap industry amounted to 40 million tons, an increase of only 3 million tons versus a 16 million ton rise in raw steel output. In the intervening time, our throw-away society has come into full bloom. It reached its nadir with people literally throwing away their automobiles by abandoning them on city streets, in country lanes, or along our highways. Tin cans are a modest problem in relation to cars.

Most of the impact of the decline in scrap demand in relation to basic steel production has been felt in the consumer goods area--as exemplified by the old car, which is so obvious, but to a lesser degree by other consumer hard goods, such as refrigerators, stoves, washing machines and the like.

In its drive to make use of this available raw material, our recycling industry in the past 10 years has developed the automobile shredder, an expensive system of hammer mills, magnetic separators, conveyors, furnaces, along with accompanying air, dust, and water systems. Large systems cost upward of $6 million, when accompanied by non-ferrous metal separation devices. Smaller systems now start at $600,000. There are close to 80 such systems in operation today, and there will, in all likelihood, by 100 by this time next year.

Within the context of today's program, the automobile shredder stems from the tin can shredder, developed in the Thirties for providing shredded tin cans for the copper industry in the West. Tin can shredding started in Los Angeles, and, during World War II spread to Houston, and then to other locations.

Shredded tin cans are used in large-scale copper leaching operations in the West. The method used goes back to Rio Tinto in Spain in the mid-seventeen hundreds. Nearly 13 percent of the total copper production in the Western States in 1965 was obtained from the precipitation of copper from leach liquors by using metallic scrap iron.

Virtually all of the copper leaching operations in the United States use shredded tin cans. We estimate that about 350,000-400,000 tons of this material is consumed annually. Copper companies are also experimenting with shredded automobile scrap, sponge iron, and pre-reduced iron pellets.

A member company of my association has told me that the problem with tin cans West of the Mississippi is not getting rid of the cans, but rather of finding enough tin cans at an economic price to meet the needs of the copper industry. Copper producers, I am sure, would not be experimenting with other iron sources if it were possible to lay down shredded tin cans at a price and in the volume they require. But the leaching process is growing in scope, and we can expect steadily increasing demands for tin can scrap from this area providing they can be economically furnished. But, as you can readily understand, the volume of tin cans consumed by this method is modest when compared to the volume of tin cans arising annually in all parts of the United States.

The major factor other than demand which inhibits greater volume movement of cans from the large populated areas of the Eastern United States, to the copper-leaching operations of the West, is, of course, transportation costs. A number of years ago, one of our Southern members was actually forced to shut down a tin can recovery operation because of the unwillingness of the railroads to provide rates which would make it economically possible to move the cans to the consuming point.

For the purists, use of tin cans in leaching does not represent the ultimate in recycling, since the iron goes into solution with sulfur, but it does represent a viable and growing method of moving at least a portion of the tin cans which are discarded annually.

But we are really dealing with a much greater problem--the upwards of five million tons of steel used annually in the production of containers, and the fact that much of this is not recycled now, but more is likely to be recycled in the future.

During World War II, cans from city incinerators, when baled, went to steelmakers, mostly for use in blast furnaces. But in the years since, this has dwindled to virtually nothing.

Also during World War II, large tonnages of suitably prepared used tin cans were detinned, resulting in the recycling of large quantities of both steel and tin. The function of detinning, and the practice of detinning is well known, but in the post-war years, the economics have not been right for detinning of much other than prime material, consisting of can industry production scrap and rejects, as well as steel industry rejects, and scrap left from other manufacturing operations where tinplate has been used.

It has only been in relatively recent months that the canmaking industry, in protection of its markets against the onslaught of environmentalists who want to ban the can or the one way container, has instructed detinning subsidiaries it may own to start taking in general run tin cans for processing. This is, however, a modest contribution to the solution of the overall problem, and, I would venture to guess, not an easy one for the detinners on the basis of economics and their productive processes.

More importantly, as most of you are probably aware, the can industry has now offered the facilities of all can plants throughout the nation as collection centers for cans of any type, whether they be food cans, beverage cans or aerosol cans.

This is predicated on the willingness of our industry to bale the cans and on the willingness of the steel industry to accept the baled material from the metal recycling industry.

Cans in volume have not been acceptable to the steel industry because of the tin coating and also because of the lead solders. I am sure Mr. Makar will be dealing with the reasons in his paper. But just so long as the steel industry is unwilling or unable to accept can scrap, then our industry is unable to handle it on a recycling basis.

However, tin plate makers within the steel industry have been as concerned for their tin plate markets as the can industry has been about its markets. Research, as you probably know has been conducted at several of the principal companies. National Steel has melted baled tin cans in its basic oxygen furnace; United States Steel has run cans through its blast furnace in the ironmaking department; and Bethlehem Steel has handled the electric furnace application.

With the completion of this work, each of these companies has agreed to work with the can industry and our own industry in taking back baled tin cans. Republic Steel will also take back cans, and some smaller companies are interested. The American Iron and Steel Institute is currently working on a specification for baled tin cans which will meet the needs of its members, and which will also be applicable for the metal recycling industry.

A market at $20 a ton is modest, especially when the cost of transportation to the consuming point is considered, coupled with the cost of baling. In washington, recently, members of our industry met with a can company official to discuss the possibility of setting up a recycling program for the Washington area. Freight rates to the principal consumer, in this case, Bethlehem Steel, are $4 a ton. Baling costs are about $8-10 a ton. If cans are collected at sites which the ordinary citizen can readily reach, such as supermarkets, the cost of containers, their placement, and their pick-up will eat up the rest of the $20 figure, according to my people. Nevertheless, we believe wholeheartedly in the need for such a program in the Nation's Capital, and will be holding more discussions about implementing this initial meeting.

Over the longer-term, the growth of the so-called "tin-less" can will alleviate some of the metallurgical problems, just as the development of thinner coatings of tin have made it easier for steel producers to accept cans back at this time. Further, if canmakers move to methods whereby solders are eliminated, the very serious lead problem can be progressively reduced. Research on all-steel tops is well on its way. These factors obviously will aid in tan can recycling. In my estimation, they are extremely important if we are to be able to recycle all the cans which are now beginning to be removed from the trash as it arrives at sanitary landfills and other disposal areas.

Despite breakthroughs which have been occurring, and the promise of further changes in the near-future, we still have a long way to go in this matter of recycling cans. One thing I can assure you--our own industry has all the available equipment needed to meet the need. If every can produced in the nation annually were ultimately recycled, our industry would have no need to install any new equipment whatsoever, except to perhaps replace balers which were worn out in baling cans. We have the tools, and we have the knowledge. We know how to make a profit in handling tin cans, providing we have tonnage markets and a workable price level. But the key word is MARKETS. Thanks to the steel industry, these markets are now developing

METALLURGICAL ASPECTS OF RECLAIMING CONTAINER SCRAP

H V Makar and H. S. Caldwell, Jr
U. S. Bureau of Mines

INTRODUCTION

Municipal refuse generated annually in the United States is estimated at 200 million tons. The metal values of the container scrap contained therein represent a substantial resource potential, but are irretrievably lost to dumps and landfill areas by current disposal methods. Based on studies by the Bureau of Mines and others, ferrous cans represent about 4.5 percent of the total refuse, or 9 million tons annually. Nonferrous metal content in the refuse is estimated at about 1 million tons. Approximately one-half of this is from aluminum packaging.

These materials do not pose a particularly severe disposal problem when compared to the total refuse generated, but once buried, they do represent an important loss of mineral resources and should not be ignored. The ferrous cans, for example, have an estimated value of 10 dollars per ton, representing an annual potential of $90 million. If upgraded to pig iron with a specified analysis, the value would be 45 to 70 dollars per ton for an annual potential of 405 to 630 million dollars. Based on 200 dollars per ton for aluminum can scrap, the aluminum packaging scrap in refuse has a potential annual value of 100 million dollars. This value would be substantially greater in the form of secondary aluminum ingot.

In spite of the potential value, ferrous and aluminum container scrap are not readily acceptable for recycling by their respective industries. One major deterrent is the metallurgical contamination caused by other metallic elements associated with these scrap materials. This paper considers some of these metallurgical aspects and describes research efforts by the Bureau of Mines to develop effective methods for refining and utilizing container scrap.

FERROUS CAN SCRAP

Metallurgically, the ferrous can scrap is unattractive because of copper and tin contamination. Both are undesirable in steelmaking, consequently there is little or no demand for the scrap. Current market value of the scrap is estimated at $10 per ton. Other elements, such as lead and sulfur, may also reach undesirable levels. Typical concentration ranges for these elements in can scrap are shown in table 1. Desirable maximum levels for these elements are also shown for comparison.

TABLE 1. - Composition of Ferrous Can Scrap Compared to Desired Analysis

	Concentration, wt. percent			
	Cu	Sn	Pb	S
Can Scrap	0.2-0.5	0.1-0.4	0.06-0.15	0.014-0.042
Desirable	.10	.06	.02	.05

Emphasis in Bureau research is on development of processes to remove and recover copper from the scrap. Investigations also include removal of the other undesirable contaminants. The current status of some of these studies are described in the following sections of this paper.

Refining Molten Ferrous Scrap

Current studies at the Bureau of Mines College Park Metallurgy Research Center are directed at removal and recovery of copper by pyrometallurgical techniques. The process includes use of sodium sulfate (Na_2SO_4) which reduces to sodium sulfide (Na_2S). Copper removal is achieved by the formation of a copper sulfide which dissolves in sodium sulfide. Tests are conducted in induction melting furnaces with capacities ranging from a few pounds to approximately 100 pounds. Figure 1 shows a typical test in which molten sodium sulfide slag is being added to a bath of molten iron.

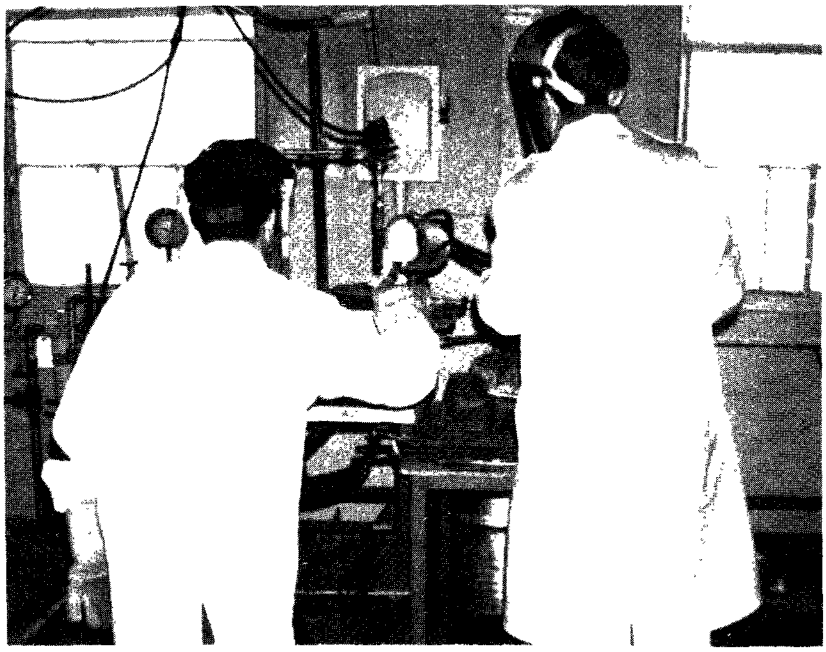

FIGURE 1. - Molten Sodium Sulfide Slag Addition to Bath of Molten Iron

Previous Research

Earlier studies at College Park defined an empirical relationship between copper removal and amount of sodium sulfate added. This relationship is illustrated in figure 2. These tests included high-carbon synthetic irons with copper concentrations up to about 1.6 percent, and actual cupola-melted auto scrap with approximately 0.45 percent copper. Final copper concentrations ranged down to 0.076 percent. Subsequent tests showed that copper levels less than 0.002 percent could be achieved if sufficient sodium sulfate were added. Based on tnis earlier work, it was estimated that the equivalent of about 800 pounds of sodium sulfate

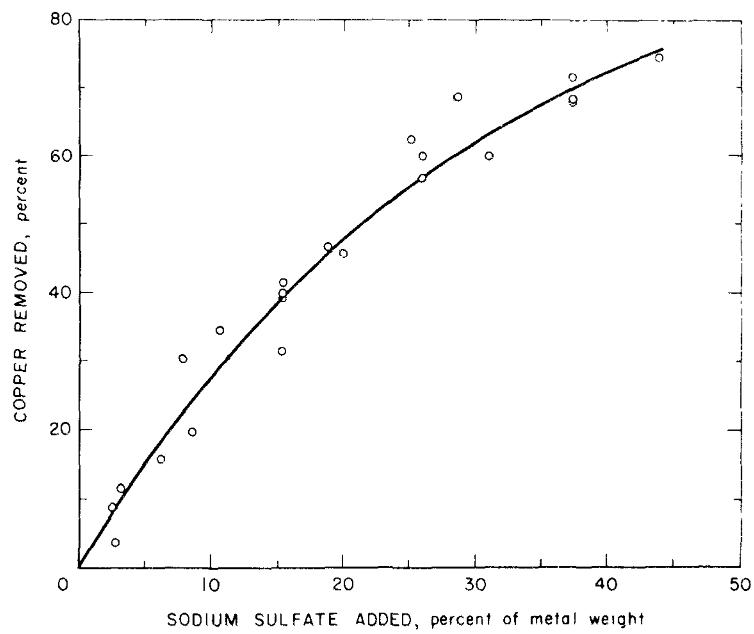

FIGURE 2. - Copper Removal vs Amount of Sodium Sulfate Added (Surface Additions)

per ton of iron treated would refine typical scrap containing about 0.40 percent copper to an acceptable level of 0.10 or less. Significant improvements in extraction efficiencies were believed possible and additional studies were undertaken. These are briefly described below.

Lance Injection

Sulfate additions during the early studies were made as a powder onto the molten iron surface. This resulted in a vigorous action on the surface of the iron bath causing some of the powder to be ejected from the furnace crucible. A lance injection system is currently being developed to overcome the inherent inefficiency of surface additions by providing controlled additions below the molten iron surface. The controlled agitation also provides an increased slag-metal interfacial area.

Initial lance injection tests on molten can scrap containing 0.35 percent copper showed considerable improvements over surface additions. Copper levels down to 0.06 percent were achieved. The results summarized in table 2 show the decrease in copper concentration as the amount of Na_2SO_4 injected is increased.

TABLE 2. - Copper Removal by Lance Injection

	Copper, wt. pct	Copper removal, pct	Na_2SO_4 added, pct of Metal Charge
Series A	0.35	-	-
	.20	42.9	9.7
	.13	62.9	19.4
	.09	74.3	29.1
	.06	82.9	38.8
Series B	0.35	-	-
	.28	20.0	1.4
	.23	34.3	7.8
	.17	51.4	13.8
	.13	62.9	19.8
	.11	68.6	24.0

Test conditions: 1300° C - 10 g Na_2SO_4/min. Approximately 1000 g Iron charge (3.7-4.5 percent carbon).

This and the earlier data for surface additions were applied to a generalized equation expressed as:

$$Y = 100\ [1-\exp(-kX)],$$

where Y = copper removed, percent

X = sodium sulfate added, percent of metal charge

k = a constant

Average k values were calculated for both sets of data and used in the above expression to obtain separate curves for lance injection and surface additions, shown in figure 3.

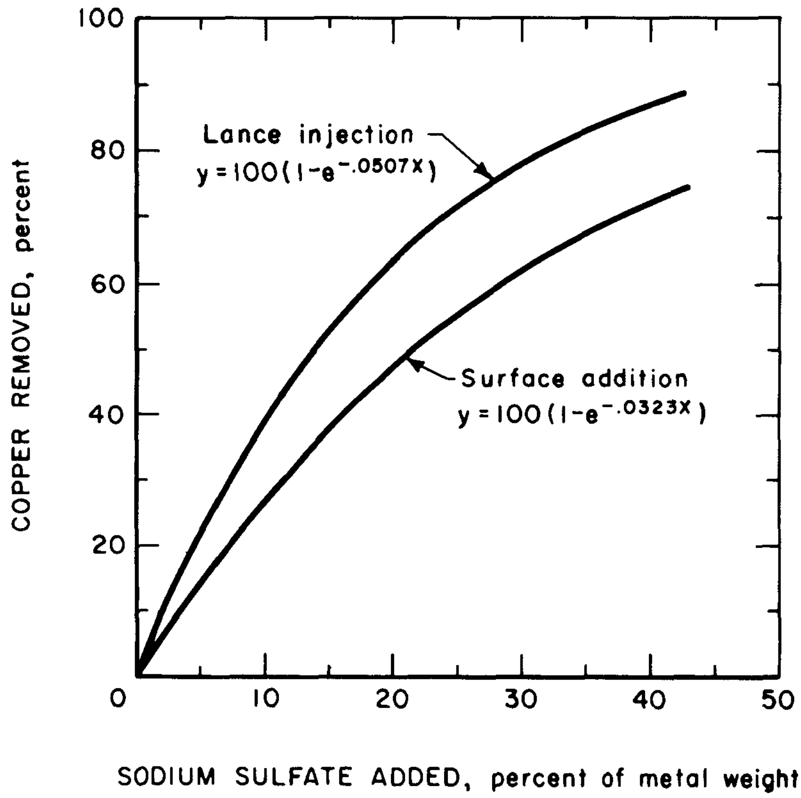

FIGURE 3. - Copper Removal vs Amount of Sodium Sulfate Added. (Lance Injection vs Surface Additions)

This preliminary comparison shows that copper removal by lance injection requires approximately 35 percent less Na_2SO_4 than by surface additions.

Slag Modification

Adjustments in the composition of the sodium sulfide slag are also being studied to determine if different slag compositions can achieve effective copper removal with smaller slag additions. Use of ferrous sulfide (FeS) in sodium sulfide slags has been found particularly effective in improving copper removal. Rate tests on molten iron with approximately 1 percent copper were run using sodium sulfide with 10-, 20-, and 40-percent additions of ferrous sulfide. The test results, when compared to similar tests using only sodium sulfide on the molten iron, showed increased copper extraction with increased ferrous sulfide content. This data is summarized below in table 3.

TABLE 3. - Copper Removal with FeS Additions to the Slag

	Copper Concentration, wt. pct		Pct Removed
	Initial	Final	
100% Na_2S	1.13	.55	56
10% FeS(a)	1.20	.44	63
20% FeS(a)	1.27	.45	65
40% FeS(a)	1.11	.31	72

(a) balance = Na_2S

Test Conditions: 1300° C, approximately 1000 g iron (3.1-5.2 percent carbon), slag added in molten form (200 g total).

Slag analyses indicated that use of ferrous sulfide also had a beneficial effect on iron recovery. Iron content of the final slags were 6.97, 10.2, and 15.6 percent for the 10-, 20-, and 40-percent ferrous sulfide additions, respectively. The initial iron concentrations were 5.42, 10.2, and 22.5 percent, respectively. In similar runs where the initial slags were all sodium sulfide, final iron concentrations in the slag ranged from 6 to 14 percent. The iron in these latter slags came from the iron bath whereas, in the slags with FeS, most or all the iron came from the FeS.

Spent Slag Recycling

The principal objective in the approaches described above has been to reduce the quantity of refining slag required to effectively remove copper. Another approach currently under study is the treatment of waste slag from the refining process to generate fresh sodium sulfate. The principle behind this approach involves oxidation of sodium sulfide in the slag to sodium sulfate. Impurity metal sulfides dissolved in the sodium sulfide are insoluble in sodium sulfate and should separate into a concentrated sulfide layer. The technical feasibility of this approach was first demonstrated by lancing molten sodium sulfide with oxygen to convert it to sodium sulfate. Subsequent tests included sodium sulfide containing dissolved copper, tin, manganese, and iron sulfides. Lancing the molten sulfide mixture at 1200° C with oxygen produced a sodium sulfate top layer and a concentrated metal sulfide bottom layer. An illustration of the separation achieved is shown in figure 4.

FIGURE 4. - Sodium Sulfate (top layer) and Metal Sulfide Concentrate (bottom) after Oxygen Lancing of Molten Sulfide Mixture.

The amount of oxygen used during the conversion process was close to the stoichiometric amount indicated by the sulfide to sulfate reaction. Analyses of the original sulfide and the resultant layers were as follows (in weight percent):

TABLE 4. - Metal Content of Slag Products - Synthetic Slag

	Cu	Sn	Mn	Fe
Original Sulfide	5.50	2.54	1.96	2.88
Sulfate Layer	.02	<.01	.002	.003
Bottom Layer	23.5	3.87	7.65	10.9

Similar tests were then performed on actual waste slag from previous iron-refining experiments. Total copper, manganese, and iron in the sodium sulfate product was less than 0.1 percent. Analyses of the waste slag and resulting layers are shown (in weight percent) in table 5.

TABLE 5. - Metal Content of Slag Products - Actual Slag

	Cu	Mn	Fe
Waste Slag	2.91	2.70	14.6
Sulfate Layer	.01	.01	.02-.05
Bottom Layer	4.80	4.81	27.7

Copper Recovery

Exploratory tests have been conducted to determine feasibility of recovering copper from the waste slag. During one test, a sample of cuprous sulfide (Cu_2S) under a layer of molten sodium sulfate was treated with ferrous can scrap. This produced a small copper button and small copper beads throughout the solidified melt. A similar test conducted on cuprous sulfide without sodium sulfate produced a substantial copper button, representing 78 percent of the total copper available. Figure 5 shows the copper button obtained, analyzing 90.4 percent copper and 7.6 percent iron.

FIGURE 5. - Copper Metal Obtained by Treating Sulfide Concentrate With Iron Scrap. (90.4% Cu and 7.6% Fe).

The overall process concept is thus one of iron refining, slag recycling, and copper recovery to produce marketable products and by-products for recycling.

It is important to note here that in the studies to date using sodium sulfate, copper removals have been achieved without sulfur pick-up in the iron. In fact, sulfur removals generally accompany the copper removals. For example, can scrap containing 0.03-0.04 percent initial sulfur contained only 0.01-0.02 percent sulfur after lance injection with sodium sulfate.

Miscellaneous Research

A number of other related ferrous scrap research projects have also been conducted or sponsored by the Bureau of Mines. Some of these are briefly described in the following paragraphs.

Increased Use of Ferrous Scrap in Electric Furnace Steelmaking

Studies are in progress at the Albany Metallurgy Research Center to develop continuous charging procedures for electric furnace steelmaking to permit wider use of secondary ferrous materials at lower operating costs. Compared to conventional batch practice, tests with continuous charging showed:

(1) approximately 50 percent reduction in heat times;

(2) about 20 percent reduction in energy consumption;

(3) reduction of residual elements to final concentrations acceptable for most steel products.

Basing their opinions on results to date, Bureau engineers believe that ferrous can scrap, as well as prepared automobile scrap and large appliance scrap, would be acceptable charge materials.

Destructive Oxidation of Ferrous Scrap

A possible solution to the ferrous scrap problem is destructive oxidation at elevated temperatures to produce an iron oxide product and clean scrap products suitable for steelmaking. The Bureau has been conducting such research in its 36-foot rotary kiln at Twin Cities.

Early tests were performed on sheared auto scrap at 1100° C. Seventy percent oxidation was achieved on incinerated as well as unburned scrap charges. Light gage material yields a single kiln product consisting of iron oxide. Heavier scrap charges can be removed as a usable product or recycled through the kiln. The destructive oxidation treatment has been shown to be applicable to tin cans as well as turnings and borings, auto scrap, and appliance scrap.

Foundry Pig Iron From Ferrous Scrap

Production of commercially acceptable foundry iron from low-grade ferrous scrap is currently under study at the Bureau's Metallurgy Research Center in Twin Cities, Minnesota. This foundry research is being conducted in an 18-inch, basic-lined cupola. The objective is to determine mixtures and processing variables to make commercially acceptable foundry iron from low-grade scrap iron at commercially attractive costs.

During preliminary testing iron was produced from various materials including select auto bundles, cleaned cans, and kiln processed auto scrap. Detailed results of these tests are shown in table 6.

TABLE 6. - Operating Data From Hot Blast Cupola Melting

	Bundles(a)	Cleaned cans	Processed auto scrap (b)
Charge, lbs/ton hot metal			
Scrap	2243	2339	2146
Coke	425	404	331
Limestone	121	106	78
Spar	27	29	26
Ferrosilicon	41	32	29
Metal analysis, wt. pct			
C	3.13	3.87	3.00
Si	.27	.42	.15
S	.18	.21	.24
Mn	.16	.14	.11
Cu	.12	.06	.14
Ni	.05	.06	.12
Slag Basicity $\frac{CaO + MgO}{SiO_2 + Al_2O_3}$	.79	.63	.47
Metal Recovery, percent	89.1	85.5	93.2

(a) Approx. 6 X 6 X 12 inches.
(b) Equal weight of +2- and -2- inch kiln processed scrap product.

Copper contents of the melted products were low, particularly for the product from can scrap which was 0.06 percent. This copper level would be considered acceptable for virtually all applications.

Use of Ferrous Scrap as a Reductant

A large portion of our domestic iron ore reserves contain iron in the form of nonmagnetic minerals such as hematite. Being nonmagnetic, these ores do not lend themselves to magnetic separation normally used for concentrating many low-grade ores. Bureau engineers at the Twin Cities Research Center have been developing a scrap iron-ore roast process that converts nonmagnetic iron minerals to magnetite, permitting subsequent concentration by magnetic separation. During the process, a mixture of ore and scrap is processed through a rotary kiln at 1000° C. Results have shown that thin-gage auto scrap, tin cans, borings, and turnings are the most effective scrap feed. Heavier ferrous scrap may not completely oxidize in the kiln, although it can be collected and used as high-quality melting stock for electric furnace steelmaking. Other secondary commodities which have been effectively used in magnetizing roasts include appliance and household scrap, and municipal refuse.

Results of tests on municipal refuse and auto scrap are summarized below in table 7.

TABLE 7. - Ferrous Scrap as Ore Reductant

Scrap	Analysis of Ore Concentrate, wt. percent		Iron Recovery, Percent
	Fe	Cu	
Municipal Refuse	67.5	0.08	90.7
Auto (sheared, unburned)	67.3	0.02	91.2
Auto (ripped)	64.4	0.03	93.6

Copper and Tin Removal by a Leach and Roast Process

Leaching of shredded ferrous can fractions in an ammoniacal ammonium carbonate solution has shown that final copper levels of 0.06 to 0.08 percent can be achieved. Residual tin levels of 0.04 to 0.06 percent can be attained by roasting the ferrous can scrap with chlorides in the presence of an oxidizing agent, followed by a wash and second roast under reducing conditions.

Utilization of Ferrous Urban Wastes

Bureau-sponsored research is being conducted at the University of Wisconsin to investigate the metallurgical effects of contaminants such as copper, tin, and nickel in ferrous metal reclaimed from urban refuse. Physical and chemical tests are being performed on ferrous castings produced by standard foundry procedures to determine tolerance levels for the contaminating metals.

Basic Studies on Iron-Copper Alloys

Bureau-sponsored research is also being conducted at Pennsylvania State University. The object of these studies is to obtain basic thermodynamic data on copper in iron-copper alloys at elevated temperatures. Such data will aid in the development of effective processes for copper removal from ferrous scrap.

Non-Cracking, Copper-Containing Steels

Scaling characteristics of copper-containing steels are being investigated at the Bureau's Albany Research Center to determine if special additions, such as silicon and aluminum, can reduce or prevent ingot cracking attributed to the presence of copper. If successful, such an approach could permit wider use of copper-bearing scrap in steelmaking.

NONFERROUS SCRAP

Research in the Bureau of Mines is particularly oriented to instances where salvaged materials may comprise a large percentage of the total supply of a commodity. In this instance the commodity is the nonferrous metal fraction of refuse and the salvaged materials are aluminum, zinc, copper, lead, tin, and magnesium. Many of these metals, particularly aluminum, are present as a result of disposal and collection of metal containers. The reclamation and reuse of these materials is of primary concern to all of us interested in meeting rapidly increasing metal production needs and conserving the diminishing mineral resources.

Part of the current research concerns the urgent need for better methods to rapidly identify metals and alloys in the nation's scrap yards. Where it can be applied, segregation is the most economical form of refining. This would be particularly desirable in retrieving aluminum containers from municipal wastes. The composition of aluminum cans is known, and once segregated from other wastes, they are rapidly reprocessed.

Research is being conducted to develop rapid and accurate identification methods to minimize costly errors in sorting, thereby reducing the quantity of scrap being discarded or processed inefficiently because of its uncertain composition. Rapid separation methods based on color reflectance, spot testing with chemicals, electrical conductivity, X-ray, and other excitation methods are being explored. Investigation of methods of identifying aluminum alloys resulted in the development of simplified and improved chemical spot tests for the alloying elements: copper, manganese, zinc, and magnesium. Procedures also include a test for differentiating between the magnesium and magnesium-silicon alloys of aluminum and between magnesium base alloys and aluminum base alloys.

The materials required for making chemical spot tests for copper, manganese, zinc, and magnesium were assembled in kit form in a 4-inch by 6-inch carrying case as shown in figure 6. Electrographic sampling and pretreated papers are

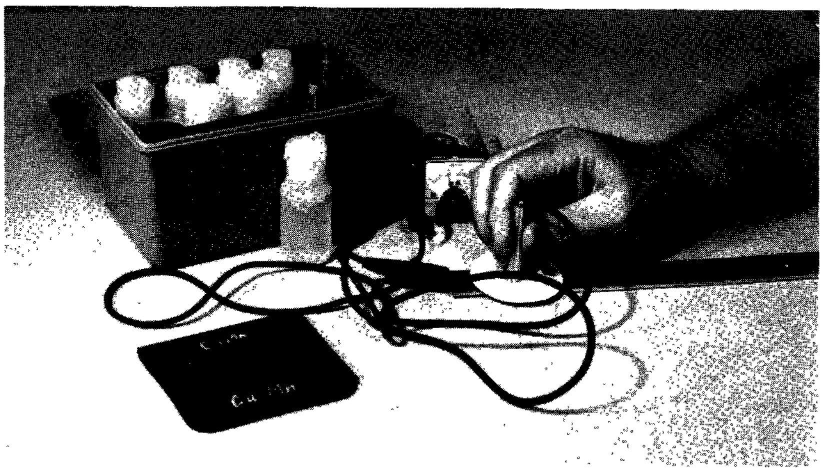

FIGURE 6. - Chemical Spot-Test Kit for Identification of Aluminum Alloy Scrap.

used in the tests. A few drops of electrolyte are applied to a piece of filter paper which has been previously treated with the indicator. A sample is dissolved electrolytically by placing the wetted filter paper between the alloy and sampling probe. The alloy is connected to the positive side of a battery. An adequate sample is obtained, and identification is made in approximately 15 seconds.

Research involving pyrometallurgical techniques presently comprise the major part of our nonferrous metal refining investigations. To date we have dealt only with the nonferrous metal recovered by the Bureau of Mines process for recycling and recovering metal and mineral value from municipal incinerator residues. The aluminum and other nonferrous containers and packaging materials melt during incineration. This nonferrous fraction is separated from ferrous and nonmetallic material and becomes a part of a complex mixture of metals and alloys of varying compositions. The Bureau is presently erecting a demonstration plant facility for the processing of raw refuse. In this case aluminum cans and containers would be readily recoverable for immediate re-smelting and re-use.

Typical compositions of the nonferrous metal collected from incinerator residues and remelted to form a homogeneous alloy are shown in table 8. Metal yield by remelting ranged from 80 to 90 percent using a commercial grade aluminum smelting flux. Due to the high amount of zinc present,

TABLE 8. - Composition of Nonferrous Metal From Incinerator Residue

Metal	Incinerator #1	Incinerator #2	Incinerator #3
Aluminum	69.5	69.2	80.0
Zinc	23.0	10.8	14.2
Copper	1.3	15.0	1.7
Lead	4.2	2.0	1.8
Tin	0.4	0.2	-
Iron	0.7	2.1	1.0
Silicon	0.2	-	1.6

this type of mixture could not be recycled in large quantities in the present secondary smelting operations. It is therefore necessary to up-grade the metal mixture by additional separations of major constituents. Two techniques presently under investigation are heavy media separation (sink-float) and vacuum distillation.

Heavy Media Separation

Samples of +4 mesh and -4+20 mesh of mixed nonferrous metals from processed incinerator residue were separated at the Tuscaloosa Metallurgy Research Laboratory at specific gravities of 2.75 and 2.95 using liquid tetrabromoethane. The sink-float fractions were then returned to the College Park Metallurgy Research Center where they were smelted to produce metal ingots for analysis. Weight percentages of the sink and float products and analysis after smelting are summarized in table 9.

The results in table 9 show that excellent separations into aluminum-rich and copper-rich products were achieved. Metal recovered from smelted floats contained 96 to 98

TABLE 9. - Results of Heavy Liquid Separation of Mixed Nonferrous Metals From Incinerator Residue

Product	Weight, percent	Analysis, percent				
		Al	Zn	Cu	Pb	Sn
2.75 sp.g.						
+4 mesh float	52.2	96.0	.5	.57	.2	.036
+4 mesh sink	47.8	4.4	34.3	54.8	2.7	.35
-4+20 float	49.6	98.0	.17	.16	.1	.027
-4+20 sink	50.4	4.3	34.3	49.6	3.6	1.06
2.95 sp.g.						
+4 mesh float	61.5	96.0	.16	.33	.1	.034
+4 mesh sink	38.5	1.7	41.1	47.2	3.7	.34
-4+20 float	53.4	97.0	.25	.27	.2	.058
-4+20 sink	46.6	.86	36.5	49.2	10.0	1.06

percent aluminum and metal from sinks was a copper-brass mixture with small amounts of aluminum, lead, tin, and iron. Sinks from 2.95 specific gravity separations have significantly lower aluminum contents than sinks from the 2.75 specific gravity separations. These results are highly encouraging in that separation into a high quality aluminum product and a copper-rich product, qualitatively approaching the composition of radiator scrap, has been achieved with the inexpensive technique of heavy liquid separation. Tetrabromoethane was used in these initial tests, but as indicated by previous experience, similar separations can be achieved with heavy media suspension, such as ferrosilicon in water.

Vacuum Distillation

Research in vacuum distillation has been highly successful in refining many kinds of aluminum and zinc base scrap. The Bureau spent several years during the early 1960's in developing low cost retort-distillation systems for treating up to 3500 pounds of scrap per retort charge. Figure 7 shows the unit during operation. Figure 8 shows the deposition of zinc in the condenser during a test with zinc die-cast scrap.

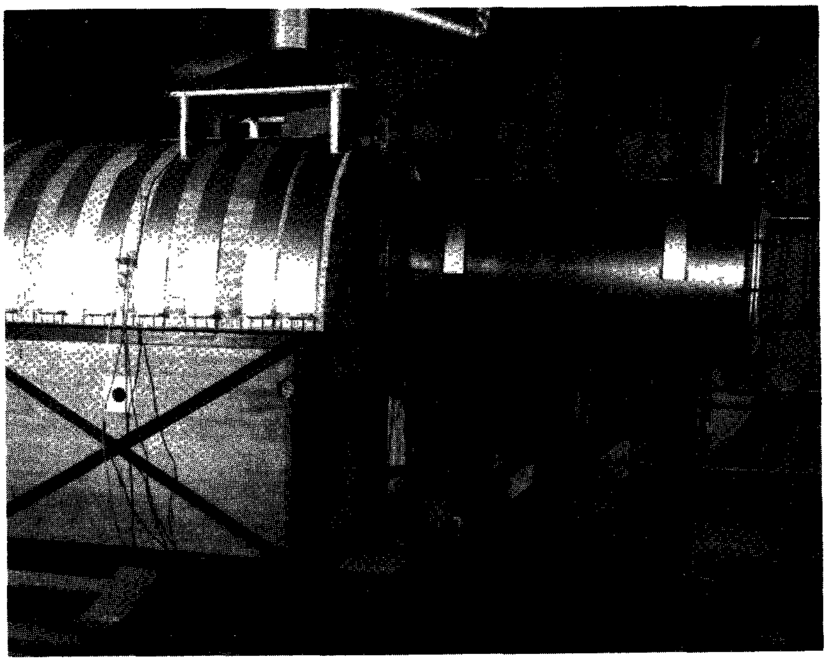

FIGURE 7. - Retort-Distillation System During Refining Operation on Zinc Die-Cast Scrap.

This type of unit was designed for operation at 850° and 50-micron pressure and would be suitable for removing and recovering zinc and magnesium from nonferrous metal refuse fraction.

Smelting and vacuum distillation results are summarized by presenting a typical test of heavy and light metal fractions obtained by jigging. Jigging produces similar products to those obtained by heavy liquid separation, except for the higher percentage of aluminum in the heavy metal fraction. The light metal fraction was found to contain approximately 88 percent metallics and 12 percent nonmetallics.

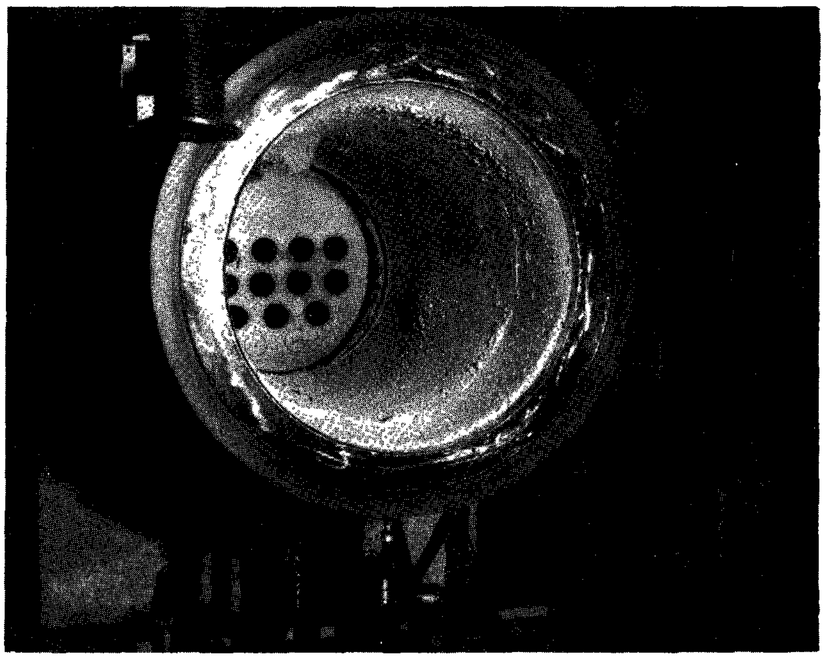

FIGURE 8. - Zinc Deposition in Opened Condenser of Retort-Distillation System

Smelting with or without a flux for either fraction produced a metal recovery of approximately 80 percent of the available metallic in the sample. Smelting temperature for the light fraction was 750° C for the heavy fraction 900° C. After smelting, metal from each fraction was vacuum distilled at 750° C for 120 minutes. Analytical results are presented as weight percent in table 10.

TABLE 10. - Analysis of Nonferrous Fractions After Smelting and Vacuum Distillation

	Light Metal Fraction		Heavy Metal Fraction	
	Smelted	Distillation	Smelted	Distillation
Aluminum	96+	98+	26.9	40.0
Copper	0.30	0.38	32.1	56.0
Iron	0.66	0.66	0.68	1.06
Nickel	-	-	0.48	0.71
Lead	0.05	0.11	2.60	1.30
Tin	0.03	0.01	1.22	1.76
Zinc	0.63	0.004	33.0	0.20
Magnesium	0.59	0.04	-	-
Manganese	0.35	0.33	-	-

Distillation condensates were remelted and analyzed. Major constituents in the light metal fraction was zinc and magnesium. The condensate from both the heavy metal fraction and light fraction analyzed better than 99 percent zinc.

Although every research endeavor being carried out by the Bureau on container scrap and solid waste reclamation has not been covered in this paper, it should suffice to point out that a serious and energetic program is being undertaken. It is also hoped that the Bureau of Mines Research effort will help to identify the opportunities and provide the data for solving some of our container reuse and disposal problems.

RECOVERY AND UTILIZATION OF ALUMINUM FROM SOLID WASTE

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Reynolds Metals Company

The author of the phrase, "Solid Waste can be likened to an Urban Ore," will probably remain unknown, but the relevancy of that single statement is becoming more apparent every day. For those in industry who have undertaken the task of providing a steady stream of raw materials to the American economy, this resource, if properly handled, may someday be a reliable (and renewable) source of supply.

This paper discusses Reynolds Metals Company's programs regarding the recovery and reutilization of aluminum from solid waste.

Reynolds Metals has a history of recycling consumer products dating back to 1957 when programs were initiated to recover the all-aluminum motor oil can. The inherent value of scrap aluminum reflected in the open market scrap price is 40 percent of the composite selling price of mill products compared to only 23 percent of the composite mill product selling price for scrap steel, another commonly used metal. It is this value that provides the obvious incentive for reclamation.

Reynolds interest in reclamation of aluminum and other valuable materials from municipal refuse is directed towards both the development of this resource as a new source of supply and helping to solve the industry's "share," if such a statement can be made, of the Nation's solid waste and litter problems. It is further believed that the value of the scrap aluminum may provide some of the economic incentives to process, for recycling, the entire municipal refuse stream. The ever increasing amount of aluminum used in the consumer sector, and eventually discarded, makes the American garbage can an important (and increasing) source of metal that is virtually expropriation proof. Included in the *daily billion pounds of refuse generated in American* homes today are approximately 5 million pounds of aluminum, as well as some 70 million pounds of steel, 2 million pounds of copper, 1/2 million pounds of zinc, and lesser amounts of other metals. The aluminum currently lost in this refuse heap amounts to about 20 percent of the total reduction capacity of this country, and the ferrous fraction amounts to about 10 percent of the country's production.

In order to pursue the Company's aluminum recovery goals, Reynolds pioneered the reclamation of all-aluminum beverage cans through a network of can reclamation facilities that are open to the general public and pay cash for aluminum cans and other used aluminum household scrap (such as foil and TV dinner trays).

Realizing that some of the population would be unable, or unwilling, to bring aluminum household type scrap to reclamation centers, the Company is now pursuing a homeowner separation program on a pilot basis. This program is designed to go where the aluminum is and to determine what is necessary to extract the valuable aluminum scrap from the waste stream at the last place it is easily identifiable, separable, and relatively simple to handle.

The third phase of the operation to recover aluminum from the solid waste stream is pointed at recovering the aluminum after it has been converted into "urban ore" by householder discard, followed by refuse collection and disposal operations. Several research efforts are currently being undertaken by Reynolds personnel. It is planned that these independent research projects complement or supplement, but not duplicate, past or ongoing research at government, university, and private levels.

Planning is also being undertaken relative to what products can be produced from aluminum and other valuable materials recovered from these various approaches to resource recovery. The amount of metal recovered, the degree of contamination, and the potential markets for the recycled products must all be considered as independent variables in our plans.

The Aluminum Can Reclamation Program

The initial achievement of a recycling program objective was in 1957 when aluminum oil cans were salvaged and recycled.

This program was continued until the all-aluminum motor oil can was replaced with composite containers. During 1967, shortly after the all-aluminum beverage can came into the marketplace, a pilot beverage can reclamation program was established in Miami. The Company worked in succession with a chain of gas stations that acted as collection centers, cooperated with a chain of grocery stores and a children's hospital, and developed a cooperative program with Goodwill Industries.

These early efforts resulted in the reclaim of up to 40,000 cans or so per month in the Miami area. However, this was a modest return compared with the cans available in the Miami area. A new approach was then developed in which the general public and interested organizations could be paid cash for aluminum turned in at a Reynolds-operated Central Can Reclamation Center.

In 1968, a Can Reclamation Center was begun in Los Angeles (Figure 1), with cans redeemed for cash. The cash payment was found to be the strongest incentive to turn in cans and other used aluminum household scrap and is the current system used by Reynolds. The rate of payment is 10¢ per pound or $200 per ton, roughly equivalent to 1/2¢ per all-aluminum beverage can. Reynolds now has Can Reclamation Centers in San Francisco, Los Angeles, Phoenix, Houston, Miami, Tampa, Jacksonville, Newark, and the Bronx and Brooklyn, New York. In addition, we have a Mobile Can Reclamation Center now in operation in the Pacific Northwest. This is a complete reclamation center, mounted on a semi-trailer and is scheduled into various communities on a regular basis. A fleet of these mobile units is now being constructed.

At our centers, aluminum is received, magnetically separated, paid for, and shredded. It is then sent in carload lots to one of the Company's smelting plants in Alabama or Virginia.

Complementing the Reynolds permanent and mobile can reclamation facilities, a number of the Nation's largest brewers and soft drink bottlers are cooperating with our program by providing locations where aluminum cans may be redeemed for cash. As

FIGURE 1. - Reynolds Los Angeles Can Reclamation Center

of this date, over 400 of these satellite collection depots are now operating in over 20 states.

In 1970, the Aluminum Can Reclamation Program brought in over 4 million pounds of aluminum, equivalent to about 80 million cans, and paid out over $400,000 to individuals and to organized groups such as the Boy Scouts. The volume of metal collected by this program is continuing to increase.

In the month of March, 1971, Reynolds Can Reclamation activities passed the one million pounds per month milestone (equivalent to 20 million cans per month) with our Los Angeles Center alone collecting over 200,000 pounds of aluminum cans. It should also be pointed out that the Aluminum Can Reclamation Program, as it is now constituted, is an economically viable system.

Householder Separation Programs

In order to recover a larger percentage of aluminum consumer scrap, while the research efforts pointed at total recycling of municipal refuse are in progress, an interim approach was decided on. This approach deals with a homeowner separation program in two selected geographic areas. These programs are being conducted in cooperation with two private refuse management companies. The purpose of the program is to determine if homeowners will, with suitable incentives, separate and save the clean, all-aluminum household type scrap they normally generate.

One of these locations, a City in Florida, is ideally suited for such a homeowner separation program. The present method of refuse collection utilizes appropriately identified plastic bags, which are purchased by the homeowner from agents of the refuse collection and disposal company for 40¢ each. These agents are grocers, filling stations, and so forth. The price of these bags includes bag cost and collection and disposal costs. The homeowner sets out his refuse on collection days and after collection no garbage cans remain at the curb to mar the beauty of the area.

Reynolds is providing 10,000 plastic bags to the refuse company, which, in turn, will give them to two separate groups of 500 homeowners each. One group will receive one free refuse collection bag and 10 of the aluminum salvage bags; the other group will be given two free refuse collection bags with 10 of the aluminum salvage bags.

Each week, for a period of 10 weeks, the homeowners will set out a plastic bag containing the past week's accumulation of aluminum cans and other clean household type aluminum scrap. Processing of the scrap aluminum collected will be done at our Miami Can Reclamation Center. Later, if volumes permit, the material will be shredded and sent directly to one of our smelting plants.

From this program we hope to get answers concerning the future of this type of recycling effort and the incentives necessary to sustain and expand it.

The other homeowner separation program, in California, will involve a number of independent refuse collectors working through their trade association. These collectors will be given a total of 25,000 plastic bags for distribution to their customers. Tentatively, the plan is for the homeowners to fill the bags with clean household type scrap and be compensated by the collector for the amount of aluminum turned in. The aluminum collected by the refuse companies will be periodically loaded into packer trucks and transported to our San Francisco Can Reclamation Center.

Both of these programs will be underway in the next few weeks. Upon completion, we will analyze the results of these pilot programs to determine their practicality for the long-term.

Research Programs on the Separation of Aluminum and Other Non-Ferrous Metals from Refuse

In this section some of the in-house research programs now being conducted by Reynolds are discussed.

Reynolds has had a pyrolysis, or destructive distillation capability, for the last dozen years. The current operation is located at the Bellwood Smelting Plant and is designed to recover aluminum from paper-mounted foil. This material is first shredded, then charged into a furnace with a controlled temperature and atmosphere. As the material is processed in the furnace, the paper and adhesives are carbonized in a low oxygen environment and aluminum oxidation is minimized. The residue from this furnace is discharged into a hammermill, where the carbon is physically separated from the aluminum. The bulk of the carbon is removed by air classification and any carbon residue left on the aluminum is burned off in a kiln. At this point, the aluminum recovered is suitable for any of several reuse options, depending on the current order requirements.

Because of this experience background, much of Reynolds in-house research on separation of aluminum from mixed refuse is based on the assumption that thermal processes--incineration or pyrolysis will be employed prior to aluminum separation.

To this end, separation and evaluation studies are being conducted on metal obtained from the U. S. Bureau of Mines pilot incinerator ash recovery system, located at the University of Maryland, College Park, Maryland.[1] The Bureau of Mines system magnetically separates the magnetic ferrous materials from Washington, D. C. Sanitation Department incinerator ash. The non-magnetic ferrous (some types of stainless steel) and non-ferrous metals are concentrated in two screen sizes (-1 1/4" + 20 mesh) and (-20 + 40 mesh). Samples of these two material sizes were obtained from the Bureau of Mines for further separation work. (This as-received material was approximately 50 - 70 percent aluminum.) This material was separated into heavy and light fractions using dense media techniques. Of the (-1 1/4" + 20 mesh) material, 67 percent was lighter than 3.0 gm/cc, and 33 percent heavier (aluminum density = 2.7 gm/cc). For the (-20 + 40 mesh) material, 57 percent was lighter than 3.0 gm/cc and 43 percent heavier.

In both of these samples, small amounts of magnetic ferrous material was found in the part that was heavier than 3.0 gm/cc. In practice magnetic separation would be used to remove this iron. Samples from both screen fractions, lighter than 3.0 gm/cc were melted under a (NaCl 50%, KCl 45%, Cryolite 5%) molten salt flux at 1500°F. Recovery of metal from the (-1 1/4" + 20 mesh) fraction was 74.7 percent, assaying 96 percent aluminum, and recovery from the (-20 + 40 mesh) material was 57 percent, assaying 97 percent aluminum. *Combining these figures* shows a net recovery of 48 percent aluminum in the (-1 1/4" + 20 mesh) fraction, and 36 percent recovered aluminum in the (-20 + 40 mesh) fraction. Bureau of Mines personnel report that the larger size fraction represents 75 percent and the smaller fraction 25 percent of the non-ferrous residue which totals about 2.8 percent of the initial ash load. Combining these figures shows a net aluminum recovery of 45 percent of the non-ferrous portion of the incinerator ash. When the other elements, alloyed with the aluminum, are included, the total aluminum alloy metal uncovered increases to 46.7 percent of the non-ferrous portion.

Another project being conducted in parallel with the previous one is an investigation of techniques to recover aluminum and other valuable materials from the char resulting from pyrolysis of municipal refuse. The current samples of char under investigation are from Monsanto's "Landguard" pilot plant in St. Louis. The aluminum content of municipal refuse in St. Louis is relatively low due to an almost complete absence of aluminum beverage cans in that area. Therefore, Reynolds supplied samples of household type aluminum scrap, to be added to raw municipal refuse on a controlled basis, in order to bring the aluminum up to percentages anticipated in high aluminum can use areas ($\sim$3 percent) and provide for a better yardstick to measure metal loss and evaluate subsequent aluminum recovery techniques.

The pyrolysis operation was conducted at a temperature of 1000^{o} - $1500^{o}F$, based on exhaust temperatures from the pyrolysis unit. The char was water quenched as supplied to Reynolds, with a water content of 40 percent.

Initial separation experiments, just completed, were conducted as follows:

A. Magnetic separation to remove iron

B. Wet screen to (+ and - 7 mesh) fractions

   1. Ball mill the (+7 mesh) material to separate the carbon and glass

2. Rod mill the (-7 mesh) material to flatten the metal and separate the carbon and glass

3. Use dense media to separate the ball and rod mill outputs into fractions heavier and lighter than 3.0 gm/cc

4. Dry all material

5. Char analysis, dry, is based on combining similar materials from both dense media separations and is:

    Ferrous (magnetic) - 38%
    Aluminum with a small amount of glass - 3.5%
    Glass - 2.2%
    Other non-ferrous - 0.6%
    Balance of char, ash, fines, glass - 55.7%

C. An independent lab analysis of the char, ash, fines, and glass fraction shows it to be 13 percent carbon. These figures are tentative, of course, and will be verified over a larger group of samples. However, these are given to provide approximate figures.

Reynolds is also considering an investigation into the use of an applied field, such as a magnetic field, to be used in conjunction with ferromagnetic particles such as ferrosilicon, magnetite, and so forth, as a variable density dense media separation system.

This research work, in general, has been conducted under the following qualitative guidelines:

1. Much of the past work conducted on refuse recycling has concerned itself with reuse of large bulk items, such as paper or in the manufacture of compost. This approach can alleviate a solid waste disposal problem, but can result in the anomaly of generating a marginally saleable end product.
2. The recovery of less bulky, but potentially more valuable solid waste items, such as ferrous and non-ferrous metals has been neglected.
3. The reclamation of minor weight percentage fractions of refuse must be preceded by salvage, conversion, or destruction of the major bulk

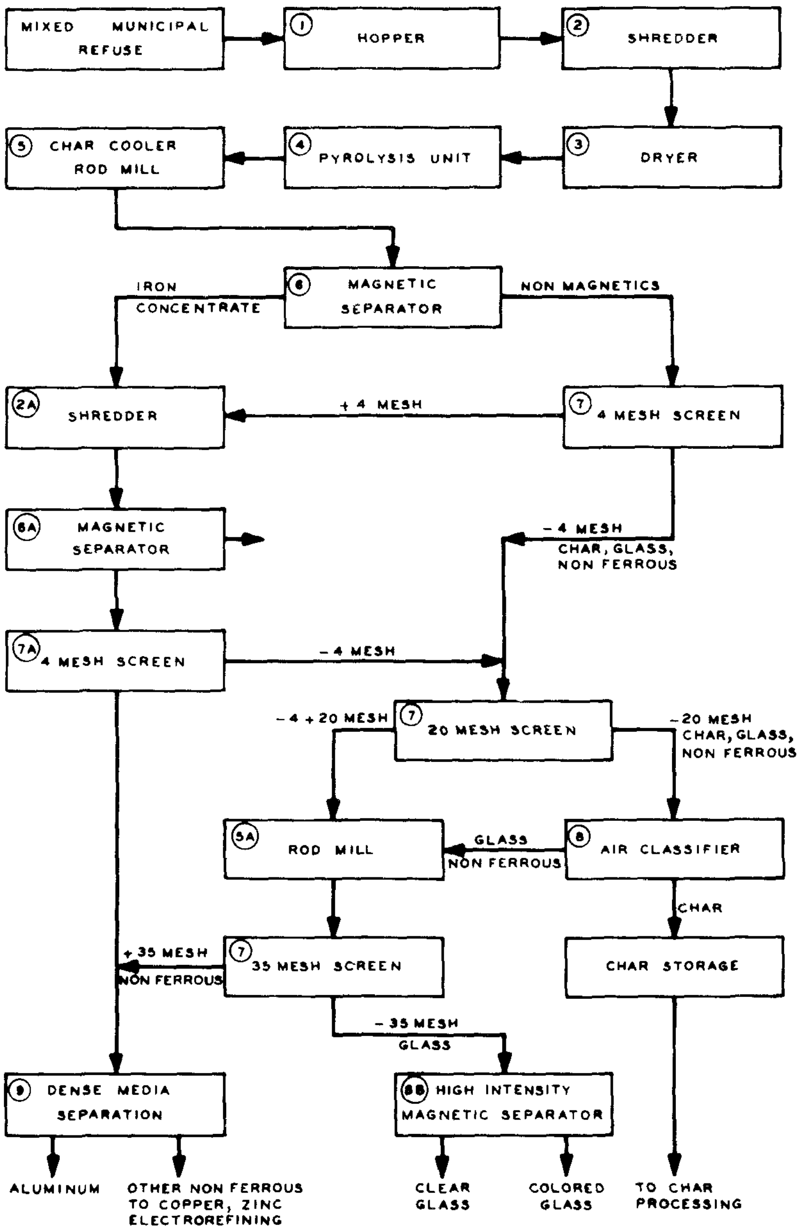
items in refuse.

4. The removal of the major bulk items in refuse, by whatever means, should be compatible with the eventual recovery of the minor volume and/or weight constituents having a high potential salvage value.

5. Since most metals in municipal refuse are in an uncombined state, it is best to utilize as many of the physical characteristics of the individual metals as possible in separation and to conduct recovery operation in such a manner as to preclude oxidation or alloying.

On the basis of these guidelines and work done so far, a flow chart of a projected pilot scale total recycling processing system has been developed. This approach, it is believed, can maximize the recovery of theindividual, valuable, low volume constituents while providing substantial volume and weight reduction of the major constituents. The flow chart shown in (Figure 2) outlines the basic system requirements.

FIGURE 2 SOLID WASTE RECYCLING PILOT PLANT



Product Potential of Recycled Aluminum

In parallel with work on one or more techniques to separate the valuable materials from raw municipal refuse, incinerator ash, or pyrolysis char, work is ongoing to utilize the recovered materials in the new products. Obviously, there is a tradeoff involved here. There is no technical reason to preclude recovery of 99 percent pure or 99.9 percent pure aluminum, for example. Presumably, such refinement could be carried out to the extent that the recovered metal would be virtually unlimited it its use wherever aluminum can be normally employed. At each decreasing level of purity, a smaller spectrum of products is possible, but the overall recovery cost is lower. Hence, at Reynolds, new product investigations are being conducted as a function of the purity of the recovered metal so that cost/benefit determinations can be made for the recovered product.

There are many conventional uses for many of the materials recovered from municipal refuse. These range from glass cullet being converted into children's marbles, spun glass insulation, and the newly developed "Glasphalt" paving material, up to precious metals recovered from incinerator ash.

For example, selenium is a metal that is sometimes recovered from the ashes of coal burning power stations, since the selenium bearing ores are sometimes mixed in veins of coal. Selenium is used in applications from semi-conductors to dandruff remover shampoo.

There are many current, rather conventional uses for aluminum recovered from our can recycling programs. Foremost among these is the remelting of shredded cans received from the public through our can reclamation centers. This remelted metal is cast directly into new ingots which can then be rolled into new can making material. The energy required to remelt aluminum scrap is so low relative to some of the other commonly used packaging materials, that often after two or three recyclings of an aluminum can, the cumulative energy content of aluminum cans becomes the lowest of major can making materials, irrespective of their recyclability.

In addition to new cans, products such as highway culverts, residential siding, industrial siding and roofdeck, gutters and downspouts, lawn furniture, and countless other products can be made directly from recycling aluminum cans. In general, the aluminum cans and used household scrap brought back through the can reclamation program can be used wherever it is needed in our product mix. Because of the relatively high manganese content in the 3004 alloy can body stock, the ideal use for this recovered material is back into can making.

While our experience with aluminum recycled from municipal refuse is limited at this time, we know what aluminum alloys go into the various products that are usually found in the refuse heap. Products that potentially can be made from such recovered aluminum are many if not all of the products that can be made from recycled aluminum cans. We also feel that aluminum for automobile radiators, aluminum engines, pistons, and so forth, could be produced, with some addition of other alloying elements. Products such as steel deoxidizers, explosive intensifiers, thermite additives, plastic fillers, and so forth, could be produced with aluminum recovered from municipal refuse. The list could go on indefinitely with very few products that could not be made from this aluminum.

There may also be new, unconventional uses for the metallic components, as well as some of the other materials recoverable from municipal refuse.

For example, we may be able to cast recovered aluminum into a billet and extrude it into structural members for housing construction. Iron, magnesium, silicon, zinc and copper could well be standard "contaminants" in aluminum recovered from refuse and would add strength to the final product. In cold climates, today's aluminum joist conducts the cold from an exterior wall to an interior wall and causes condensation at that point. The affected surfaces of these extrusions might even be coated with other reclaimed material such as pulverized glass, using recovered thermoplastics to bond the glass to the aluminum and give a thermal break at these critical surfaces.

Summary

The purpose of this paper has been to present a brief progress report on Reynolds Metals Company's activities on reclaiming aluminum from solid waste and developing uses for this material.

The Company's Aluminum Can Reclamation Program is now reclaiming over one million pounds per month of aluminum cans and other used aluminum consumer products. This scrap material is ideally suited for making new aluminum cans and can readily be used within the Company's product mix.

Pilot scale householder separation programs for aluminum will be underway shortly to explore the feasibility of this approach as a means of supplementing the ongoing reclamation program.

Preliminary results from laboratory scale studies have developed processes by which relatively pure aluminum can be extracted from incinerator ash and pyrolysis char. A new Reynolds Product Development Division program now underway indicates that there may be a broad spectrum of new aluminum-based products that can be made from alloy combinations obtainable from municipal refuse.

Based upon the laboratory work to date, flow charts have been developed for a pilot-scale complete processing system for refuse.

Reynolds Metals Company is committed to the concept of recycling as an approach that will open up new sources of material supply and simultaneously provide long-term solutions to the Nation's solid waste problems. The Company's multi-front approach to this challenging problem area will continue and expand in the years ahead.

REFERENCES

(1) Spendlove, M. J., Sullivan, P. M., and Stanczyk, M. H., "Solid Waste Report", U. S. Department of Interior - Bureau of Mines, undated report.

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